STEP APPLICATION HANDBOOK

CONTRACT NO.: N00140-97-D-R191
CDRL SEQUENCE NO.: B001
RAMP PROGRAM DOCUMENT NO.: OCR2017001-0
1 June 2000

PREPARED FOR:
DEFENSE LOGISTICS AGENCY
FORT BELVOIR, VA 22060-6221

PREPARED BY:
SCRA
5300 INTERNATIONAL BOULEVARD.
NORTH CHARLESTON, SC 29418

Foreword

The development and implementation of STandard for the Exchange of Product model data (STEP) is dynamic and on-going. "STEP" is actually a series of standards, developed by experts worldwide, under the auspices of ISO 10303, Technical Committee (TC) 184, Sub-Committee (SC) 4. A handbook such as the following represents a “snap shot” of the information as it exists at this point in time.

The Rapid Acquisition of Manufactured Parts (RAMP) Program has concentrated on STEP-Driven Manufacturing of Mechanical piece parts and Electrical/Electronic Printed Wiring Boards and Printed Wiring Assemblies.

Although much of the work on (STEP) is currently addressing Product Data Management (PDM) and XML web-based implementation methods, these two items along with STEP as it relates to the Building, Process Plant, and Shipbuilding Industries will be referenced, but not extensively addressed in this document.

This handbook will concentrate on identifying the application domains being covered by STEP development, identifying commercially available tools for using STEP, and providing guidance on using the STEP technology that is currently available. It will address those STEP Application Protocols (AP’s) that have achieved (or “very soon” will achieve) International Standard (IS) status, those AP’s that are currently implemented and have commercially available translators, and those AP’s that have been or are currently being piloted, prototyped, or proved-out.

This handbook is intended as a collection of information on the current state of STEP and it’s current usability. It is intended to provide information of value to engineering users with a need to exchange product data with customers and/or suppliers.

An attempt has been made to distinguish between what is “real” now and what is theoretically possible in the future and to identify some of the current obstacles to achieving the ultimate goal of STEP (i.e., to provide a complete, unambiguous, neutral computer-interpretable standard for representing product data throughout the lifecycle of the product.)

Acknowledgements

Much information has been extracted from the many STEP related Web Sites. An attempt has been made to identify the source of most of the information, but in many instances overlapping information came from multiple sources. The information in the tables is a compilation of information from many sources. Numerous web sites are listed in the body of the handbook and in the Reference Section along with the documents at the back of the handbook. Many of the references were the sources of much of this information; some of them are simply listed for further reading beyond the intent of this document.

Particularly helpful were the PDES, Inc. Public Web Site, the SC4 Web Site at NIST, the Theorem Solutions Web Site, the UK Council for Electronic Business (UKCEB) Web Site, and USPRO.

Abstract/Executive Summary

Purpose:

This handbook is intended as a collection of information on the current state of the ISO STandard for the Exchange of Product model data (STEP) and it's current usability. "STEP" is actually a series of standards, developed by experts worldwide, under the auspices of ISO 10303/TC184/SC4. It is intended to provide information of value to engineering users with a need to exchange product data with customers and/or suppliers.

The handbook concentrates on identifying the application domains being covered by STEP development, identifying commercially available tools for using STEP, providing guidance on using the STEP technology that is currently available, and providing sources of additional information.

Content:

The handbook presents a brief introduction to STEP along with an indication of how the ISO Standardization Process works relative to STEP. The reader is made aware of the current status of STEP development with emphasis on those parts of STEP that have achieved International Standard (IS) status and those parts that will soon reach that status. The scope of each STEP Application Protocol (AP) is presented to indicate what is and what isn't addressed in the AP's. This information is presented so that the engineering user is able to see the depth of coverage of the AP's and to identify those STEP AP's and their associated conformance classes that best will meet the user's product data exchange (PDE) requirements.

A table is provided showing commercially available PDE translators from the major CAD/CAM vendors. This table includes STEP translators as well as direct translators and translators that use other PDE formats.

At this point in time, commercial implementation of STEP is still pretty much limited to several conformance classes of AP203 - Configuration Controlled Design and two conformance classes of AP214 - Core Data for Automotive Mechanical Design Processes which are roughly equivalent to AP203. Reference is made to those major companies who have put this current STEP capability into production.

Despite the limited coverage of STEP AP's in the commercial marketplace, there are (and have been) numerous pilot, prototype and proof-of-concept implementations of the many STEP Application Protocols as they have been evolving through the stages of ISO standardization. Many of these pilot projects are cited in the handbook to emphasize the successful demonstration of the power and robustness of the evolving STEP standards.

An attempt has been made to distinguish between what is "real" now and what is theoretically possible (& achievable) in the future and to identify some of the current obstacles to achieving the ultimate goal of STEP. (i.e., to provide a complete, unambiguous, neutral computer-interpretable standard for representing product data throughout the lifecycle of the product.)

Some guidance is provided for the engineering user in using the currently available STEP capability. Many obstacles have been overcome and many lessons have been learned in bringing this "first phase" of STEP implementation into production. Some hints, guidelines and checklists are provided and referenced to assist in using the currently available STEP technology.

Summary:

The STEP-related product that is commercially available to the engineering user community is essentially AP203 and its "look alike" AP214 cc 1&2 (i.e., geometry (wireframe, surfaces & solids) with some configuration management data). What is available is really very good --- good enough to be in production at Boeing, Lockheed Martin, General Motors, General Electric, Pratt & Whitney, Rolls Royce and other large companies. But STEP presents a much more powerful and robust technology beyond that currently implemented and this is being demonstrated in numerous Research & Development environments.

STEP is still misunderstood in the general engineering user community, and its potential is not fully realized, particularly in the manufacturing domain. It is still evolving, and STEP is now at a point in its evolution when a significant number of Application Protocols are reaching International Standard status. Three AP's were published as IS's in 1999 and six more are expected in 2000. STEP is and will be more than AP203. The user community needs to start looking more closely at the AP's and their associated conformance classes (cc's) to determine what components/parts of STEP best meet their requirements. The user further needs to begin referring to STEP by AP and cc. In order to realize the "full" power of STEP, the user community will have to drive vendor implementation of the AP conformance classes that meet their business objectives. In order for this to happen, strong business cases are going to have to be developed in order to get the CAD/CAM/CAE Vendors on board.

Table of Contents

List of Acronyms

2D	Two Dimensional
3D	Three Dimensional
ACORN	Advanced Control Network
AEA	Aerospace Engine Alliance - AP203/PDM Schema
AEC	Architecture, Engineering, Construction
AFNOR	Association Française de NORmalisation (French Standards Organization)
AIAG	Automotive Industries Action Group
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
AWS	Advanced Weapon System (AP203/AP202)
B-Rep	Boundary Representation
Brite EuRam	A research program on raw materials and advanced materials
BSI	British Standards Institute
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CALYPSO	Computational Fluid Dynamics in the Ship Design Process
CAM	Computer Aided Manufacturing
CAPP	Computer Aided Process Planning
CAx	Generic name for CAD/CAM/CAE
CCITT	Consultative Committee International for Telegraphy &Telephony (ISO)
CEC	Center for Electronic Commerce (at ERIM)
CIM	Computer Integrated Manufacturing
CIMSTEEL	Computer Integrated Manufacture for constructional STEELwork - AP230
CLDATA	Cutter Location Data
CM	Configuration Management
CMM	Coordinate Measuring Machine
COTS	Commercial Off-The-Shelf
DARPA	Defense Advanced Research Program Agency
CSG	Constructive Solid Geometry
DDE	Data Definition Exchange
DIN	Deutsches Institut für Normung (German Standards Organization)
DL	Data List
DLA	Defense Logistics Agency
DXF	Data eXchange Format (Public Domain from Autodesk)
DWG	DraWinG format (Public Domain from Autodesk)
ECRC	Electronic Commerce Resource Center
EDIF	Electronic Design Interchange Format (ANSI/EIA)
EDIM	Electronic Data Interchange for the European Maritime Industry
EIA	Electronic Industries Association
EMSA	European Marine STEP Association
ERIM	Environmental Research Institute of Michigan
EPISTLE	European Process Industries STEP Technical Liaison Executive (AP221)
ESPRIT	European Commission - Specific RTD PRogramme in the field of Information Technologies
FEA	Finite Element Analysis
FunSTEP	Furniture STEP

GALIA	Groupement pour l'Amelioration des Liaisons dans l'Industrie Automoblie (French)
GM	General Motors
GOSET	Operational Group for the Standard for Exchange and Transfer (French)
IDL	Indentured Data List
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IGES	Initial Graphics Exchange Specification (ANSI/ASME)
IL	Index List
IPC	Institute for interconnecting and Packaging electronic Circuits (ANSI)
IPO	IGES/PDES Organization
ISAP	International STEP Automotive Project
ISO	International Organisation for Standardisation ⇒ AWI - Accepted Work Item ⇒ CD - Committee Draft ⇒ DIS - Draft International Standard ⇒ FDIS - Final Draft International Standard ⇒ IS - International Standard ⇒ JWG - Joint Working Group ⇒ NWI - New Work Item ⇒ PWI - Preliminary Work Item ⇒ SC - Sub Committee ⇒ TC - Technical Committee ⇒ WG - Working Group
ITI	International TechneGroup, Inc.
JAMA	Japanese Automotive Manufacturers Association
JECALS	Japan EC/CALS
JEDMICS	Joint Engineering Data Management Information & Control System
JSTEP	Japan STEP promotion center
KS-STEP	Korean Ship - STEP
LM-TAS	Lockheed Martin - Tactical Aircraft Systems
MOU	Memorandum of Understanding
MariSTEP	MariTech STandard for Product Model Exchange
NC	Numerical Control
NIDDESC	Navy/Industry Digital Data Exchange Standards Committee
NIST	National Institute of Standards and Technology
NURBS	Non-Uniform Rational B-Splines
NWI	New Work Items
ODM	On Demand Manufacturing
OL	Other List
PAS-C	PDES Application protocol Suite for Composites
PDE	Product Data Exchange
PDES	Product Data Exchange using STEP
PDES, Inc.	United States/United Kingdom Consortium for Accelerating the Development and Implementation of STEP
PDM	Product Data Management
PDS	Product Data Set
PdXi	Process data eXchange Institute (AP231)
PIEBASE	Process Industry Executive for achieving Business Advantage using Standards for data Exchange (AP221, AP227, AP231)

PIPPIN Pilot Implementation of Process Plant Lifecycle Data Exchange Conforming to STEP - AP221

PISTEP Process Industries STEP - AP221 & AP227

PL Parts List

PLSSPD Parts Library and STEP for Shipbuilding Product Data

PM Product Management

POSC Petrotechnical Open Software Corporation

POSC/Caesar Petrotechnical Open Software Corporation & Caesar Systems, Ltd

PreAMP Pre-Competative Advanced Manufacturing Program

ProSTEP The Centre for STEP in Germany

RAMP Rapid Acquisition of Manufactured Parts

- ⇒ DCVE - Data Conversion & Verification Environment
- ⇒ GAPP - Generative Assembly Process Planning
- ⇒ PCA - Printed Circuit Assembly
- ⇒ PCB - Printed Circuit Board
- ⇒ STEPPlan - STEP process Planner (Formerly Generative Process Planning Environment (GPPE))
- ⇒ STEPTrans - STEP Translator (Formerly RAMP Product data Translation System for Mechanical Parts (RPTS MP))
- ⇒ STEPValidator - STEP Validator (Formerly RAMP STEP Validation Processor (RSVP))

SASIG STEP Automotive Special Interest Group (AIAG, GALIA, VDA, JAMA)

SC Sub-Committee

SEASPRITE Software architectures for ship product data integration and exchange

SCRA South Carolina Research Authority

SEDS SC4 Enhancement and Discrepancy System

SET Standard d'Exchange et de Transfert (French) (AFNOR)

SGML Standard Generalized Mark-up Language

SIS Stereolithography Interface Specification (Public Domain from 3D Systems, Inc.)

SOAP STEP On A Page

SOLIS SC4 On-Line Information System

SPI-NL Standard for Plant Information in the NetherLands

STAMP Supply-chain Technologies for Affordable Missile Products - AP232/STEP PDM Schema

STL Stereolithography

STEP STandard for the Exchange of Product model data (ISO)

- ⇒ AAM - Application Activity Model
- ⇒ AIC - Application Interpreted Construct
- ⇒ AIM - Application Interpreted Model
- ⇒ AM - Application Module
- ⇒ AO - Application Object
- ⇒ AP - Application Protocol
- ⇒ AR - Application Resource
- ⇒ ARM - Application Resource Model
- ⇒ ATS - Abstract Test Suite
- ⇒ CC - Conformance Class
- ⇒ IR - Integrated Resource
- ⇒ SDAI - Standard Data Access Interface
- ⇒ UoF - Unit of Functionality

STEPwise	STEP web integrated supplier exchange pilot
STIR	STEP TDP Interoperability Readiness pilot
TAG	Technical Advisory Group
TC	Technical Committee
TDP	Technical Data Package
TIGER	Team Integrated-Electronic Response
USPro	U. S. Product data association
UKCEB	UK Council for Electronic Business
UKCIC	UK CALS Industries Council
UKRAMP	United Kingdom RAMP
VDA-IS	Verband der Automobilindustrie - German Standard to exchange 2D CAD Geometry & dimensions (DIN)
VDA-FS	Verband der Automobilindustrie - German Standard to exchange Surface Data (DIN)
VHDL	Very High Speed Integrated Circuit (VHSIC) Hardware Description Language (ANSI/IEEE)
XML	eXtended Markup Language

Proprietary Names of Vendors and Products

Product/Vendor	Descripton
ACIS	Geometric Modeling Kernel supporting 3D surfaces and BREP solids
AutoCAD	A CAD system developed and marketed by Autodesk
Autodesk	A CAD/CAM system developer and vendor - Develops and markets AutoCAD and Mechanical Desktop
Board Station	A CAE system for Printed Circuit Board (PCB) layout design developed and marketed by Mentorgraphics
Bravo	A CAD system developed by Applicon (now part of UGSolutions)
CADDS 4X/CADDS5	CAD systems developed by Computervision
Cadence	An Electrical/Electronic CAE System Vendor
CADKEY	A CAD system developed and marketed by CADKEY Corporation
Camand Mutax	A CAM system (formerly CAMAX) developed and marketed by SDRC
CATIA	A CAD system developed and marketed by Dassault Systemes & IBM
Computervision	A company, now, within Parametric Technology Corporation
Dassault Systemes	A French CAD/CAM Company that develops and markets CATIA and SolidWorks
ECCO	An Express Compiler developed and marketed by PDTec
EPM	A Norwegian Product Data Modeling Software Company
EXPRESS Data Manager	A Suite of tools for application development and integration developed and marketed by EPM
EXPRESSO	An Express Compiler developed at NIST
FBMach	A feature-based machining system developed by Honeywel Federal Manufacturing and Technologies (formerly Allied Signal)
FEDEX	An (earlier) Express Compiler developed at NIST
GibbsCAM	A CAM System developed and marketed by Gibbs and Associates
ICAD	A knowledge-based engine marketed by KTI
I-DEAS	A CAD system developed and marketed by SDRC
InterData Access (IDA)	A company, now, within Spatial Technology, Inc. - Provides data analysis tools and services
ITI	International TechneGroupe, Inc. - A Product Data Interoperability Tool developer and vendor
KTI	Knowledge Technologies International
LOCAM	A CAM system developed and marketed by LSC Group, Ltd
MasterCAM	A CAM System developed and marketed by CNC Software, Inc.
Mechanical Desktop	A CAD/CAM system developed and marketed by Autodesk
Mentorgraphics	An Electrical/Electronic CAE System Vendor
Parasolid	Geometric Modeling Kernel supporting 3D surfaces and BREP solids
PDGS	Product Design Graphics System - A CAD System developed by Ford Motor Corporation
PDTec	A German Product Data Modeling Software Company
Pro/ENGINEER (Pro/E)	A CAD System developed and marketed by PTC
PTC	Parametric Technology Corporation
SDRC	Structural Dynamics Research Corporation
Solid Edge	A PC-based CAD system marketed by Unigraphics Solutions
SolidWorks	A PC-based CAD System marketed by Dassault Systemes (Developed by SolidWorks Corporation, now a subsidiary of Dassault)

Product/Vendor	Descripton
SmartCAM	A CAM system developed and marketed by SDRC
Spatial Technology, Inc.	Develops and markets ACIS and ACIS based tools
STEP Tools, Inc.	Provides STEP related tools, translators, and services
SurfCAM	A CAM system developed and marketed by SDRC
Theorem Solutions	A Product Data Exchange Software Tool Company in the UK
Unigraphics	a CAD system developed and marketed by UGSolutions
Unigraphics Solutions (UGSolutions)	Develops and markets Unigraphics, Solid Edge, Bravo, and Parasolid
Zuken Redac	An Electrical/Electronic CAE System Vendor

1.0 Introduction

The STandard for the Exchange of Product model data (STEP - ISO 10303) provides a neutral computer-interpretable representation of product data throughout the life cycle of a product, independent of any particular system. STEP is actually a suite of international standards built around an integrated architecture of domain specific application protocols (AP) and generic integrated resources. The AP’s break STEP into manageable and comprehensible "chunks" that can be more readily implemented.

Almost everyone involved with product design and/or manufacture, whether it is mechanical, electrical/electronic, or electromechanical, agrees on the importance of being able to exchange product data effectively among contractors/customers and subcontractors/suppliers who often use different CAD/CAM/CAE systems. Manufacturing is frequently outsourced. Accurate, complete product data is essential for the production and procurement of quality products. The issue of "standards" usually comes up in discussions about data exchange.

The SCRA houses two very STEP-centric groups: One is the Advanced Technology Institute (ATI), a separate company affiliated with SCRA. ATI is the general manager for PDES, Inc. which is an industrial consortium chartered with accelerating the development and implementation of STEP. More than twenty major automotive, aerospace and CAD/CAM vendor and user companies actively participate in their numerous STEP projects. The second is the RAMP Program managed by SCRA’s Integrated Systems Group (ISG). In addition to developing STEP AP224, the RAMP Program has implemented, proved-out and put into production STEP AP224 translation, validation, and process planning software that drives the RAMP mechanical (milling & turning) factory at the Anniston Army Depot and other installations.

In this handbook, we will present a brief introduction to STEP along with an indication of how the ISO Standardization Process works relative to STEP. The current status of STEP development will be presented with emphasis on those parts of STEP that have achieved International Standard (IS) status and those parts that will soon reach that status. The scopes of these STEP Application Protocols (AP's) are presented to indicate what is and isn't addressed in the AP's. This information is presented so that the engineering user is able to see the depth of coverage of the AP's and to identify those STEP AP's and their associated conformance classes that best will meet the user's product data exchange (PDE) requirements.

The handbook is intended as a collection of information on the current state of STEP and it’s current usability. It is intended to provide information of value to engineering users with a need to exchange product data with customers and/or suppliers.

It identifies the application domains being covered by STEP development and the tools that are commercially available for using STEP. It provides some guidance on using the STEP technology that is currently available and cites sources of additional information.

2.0 Background

2.1 ISO 10303 (STEP) Overview

(from http://www.ukcic.org/step/)

"STEP, Standard for the Exchange of Product Model Data, provides a representation of product information along with the necessary mechanisms and definitions to enable product data to be exchanged. The exchange is among different computer systems and environments associated with the complete product lifecycle including design, manufacture, utilisation, maintenance, and disposal. The information generated about a product during these processes is used for many purposes. This use may involve many computer systems, including some that may be located in different organisations. In order to support such uses, organisations must be able to represent their product information in a common computer-interpretable form that is required to remain complete and consistent when exchanged among different computer systems.

STEP is organised as a series of parts, each published separately. These parts fall into one of the following series: description methods, integrated resources, application protocols, abstract test suites, implementation methods, and conformance testing. STEP uses a formal specification language, EXPRESS, to specify the product information to be represented. The use of a formal language enables precision and consistency of representation and facilitates development of implementations. STEP uses application protocols (APs) to specify the representation of product information for one or more applications. It is expected that several hundred APs may be developed to support the many industrial applications that STEP is expected to serve.

An addition to the STEP standard that certainly will enhance its implementability and acceptance is the constraint that abstract test suites and conformance testing must be built into the standard.

The overall objective of STEP is to provide a mechanism that is capable of describing product data throughout the life cycle of a product, independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving. The ultimate goal is an integrated product information database that is accessible and useful to all the resources necessary to support a product over its lifecycle."

For more information on STEP, the reader is referred to some of the following introductory texts on STEP**:**

1. Introducing STEP - The Foundation for Product Data Exchange in the Aerospace and Defence Sectors, National Research Council Canada, C2-447/1999, Susan Gilles (ed), 1999.
2. STEP-The Grand Experience, NIST, Sharon J. Kemmerer (ed.), July 1999
3. STEP:Towards Open Systems-STEP Fundamentals and Business Benefits, Dr. Kais Al-Timimi & John MacKrell, CIMdata, September, 1996.

Several Websites to visit for Introductory/Background Information on STEP are the following:

1. Team SCRA - RAMP Product Data --- http://ramp.scra.org/pdt_summary.html
2. PDES Inc. Public Website --- http://pdesinc.aticorp.org/
3. PDES, Inc. STEP Overview --- http://pdesinc.aticorp.org/whystep.html

4. NIST SC4 Website (Updated 2000-02-08): --- http://www.nist.gov/sc5/soap/
   --- STEP On A Page
5. UK CALS Industries Council (UKCIC) Website --- http://www.ukcic.org/step/step.htm
   aka UK Council for Electronic Business (UKCEB) (Home Page) --- http://www.ukcic.org/step/
   "STEP-A Key Tool in the Global Market" (Overview) ---
   http://www.ukcic.org/step/pages/stpgolb1.htm
   Nice History of STEP http://www.ukcic.org/step/pages/history.htm
6. ProSTEP --- http://www.prostep.de/d_WIS_rahmensatz.htm (In German)

A very useful compact summary of the STEP development process with a periodic status update was developed by Jim Nell (@ NIST). Jim is the chairman of ISO TC184/SC5, but was a long time participant in the working groups of ISO TC184/SC4 (the "home" of STEP). Jim conceived the concept of "STEP On A Page" (SOAP). On the front and back of a single "piece of paper", he was able to capture a description of all of the STEP documents and a summary of their development status which he continues to maintain/update on a periodic basis. SOAP appears below. SOAP can be found @ http://www.nist.gov/sc5/soap/

PDES, Inc. also created a set of easy to understand graphics that describe the STEP Application Protocols which can be referred to as "User Friendly AP's on a Page". They can be found at the PDES, Inc. Public Web Site @ http://pdesinc.aticorp.org/whystep.html

Over the years, the International STEP community has worked very closely within the ISO TC184/SC4 working groups with international meetings occurring 3 or 4 times a year. Within most of the countries, national STEP Centers have been established. Often, as important issues would arise or affirmation of commitments were felt to be appropriate, Memoranda of Understanding (MOU's) would be signed and issued as "Press Releases". Several of the more important MOU's were the MOU's signed (in the mid 1990's) by the international aerospace companies and automotive companies committing to the support of STEP development and implementation. Four of the more recent MOU's were: (see http://pdesinc.aticorp.org & its archives)

- ⇒ the 1997 MOU on the harmonized STEP PDM Schema (viz., for AP's 203, 210, 212, 214, & 232) signed by ProSTEP, PDES, Inc., and JSTEP,
- ⇒ the 1998 MOU on the use of the STEP PDM Schema for the EuroFighter signed by BAe (UK), DASA (Germany), CASA (Spain), and Alenia (Italy),
- ⇒ the 1999 MOU on Modular Development and Implementation sign by PDES, Inc., ProSTEP, GOSET, and JSTEP, and
- ⇒ the 1999 MOU on Conformance Testing and Certification signed by PDES, Inc., GOSET, JSTEP, and C-STEP.

ISO TC184 SC4

STEP on a Page

ISO 10303

APPLICATION PROTOCOLS AND ASSOCIATED ABSTRACT-TEST SUITES

I 201 Explicit draughting [ATS 301 = W]
I 202 Associative draughting [C)
I 203 Configuration-controlled design (c2=I,a1=F)[C]
C 204 Mechanical design using boundary rep [C]
C 205 Mechanical design using surface rep [W]
X 206 Mechanical design using wireframe [X]
I 207 Sheet metal die planning and design [I]
C 208 Life-cycle product change process [W]
E 209 Composite & metal structural anal & related design[W]
E 210 Electronic assy, interconnection & packaging design [W]
X 211 Electronic P-C assy: test, diag, & remanuf[X]
E 212 Electrotechnical design and installation [C]
E 213 Num control (NC) process plans for mach'd parts [W]
E 214 Core data for automotive mech design processes [C]
W 215 Ship arrangement [W]
W 216 Ship moulded forms [W]
W 217 Ship piping [W]
W 218 Ship structures [W]
O 219 Dimension inspection [X]
O 220 Proc. plg, mfg, assy of layerd electrical products [X]

C 221 Functional data & their schem rep for process plant [W]
X 222 Design-manuf for composite structures [W]
W 223 Exch of design & mfg product info for cast parts [W]
I 224 Mech parts def for p. plg using mach'n'g feat(e2=C) [I,W]
I 225 Building elements using explicit shape rep [W]
W 226 Ship mechanical systems [W]
E 227 Plant spatial configuration(e2=A) [W]
X 228 Building services: HVAC [X]
X 229 Design & mfg product info for forged parts[X]
W 230 Building structural frame: steelwork [W]
C 231 Process-engineering data [W]
C 232 Technical data packaging: core info & exch [W]
W 233 Systems engineering data representation[A]
W 234 Ship operational logs, records, and messages[A]
W 235 Materials info for des and verif of products [A]
W 236 Furniture product and project data[W]
A Systems engineering data repres.
O Neutral optical-data-interchange format [O]
O Hi-level info plg model for prod l-c spt [O]
O Integ of l-c data for oil/gas production facility

DESCRIPTION METHODS

I 1 Overview and fundamental principles (a1=O)
I 11 EXPRESS language ref man. (e2=W,c1=I,c2=c,a1=C)
I 12 EXPRESS-I language ref man (Type 2 tech report, not a 10303 part)
W 13 Architecture and Methodology reference manual
W 14 EXPRESS X Language reference manual

INTEGRATED-INFORMATION RESOURCES

APPLICATION MODULES (Technical specifications)

D 1001 Appearance assignment
D 1002 Colour
D 1003 Curve appearance
D 1004 Elemental shape
D 1005 Elemental topological shape

D 1006 Foundation representation
D 1007 General surface appearance
D 1008 Layer assignment
D 1009 Shape appearance and layers

TS legend
O=prop-->apvl for ballot
A=NP blt circ-->NP apvl
D=DTS dev-->reg as TS
T=TS Published

INTEGRATED-APPLICATION RESOURCES

I 101 Draughting (c1=I)
X 102 Ship structures
X 103 E/E connectivity
E 104 Finite element analysis

I 105 Kinematics (c1=F)
W 106 Building core model
W 107 Engineering analysis Core ARM
W 108 Prmetizat'n&Constraints for expl geom prod mdls

INTEGRATED-GENERIC RESOURCES

I 41 Fund of prdct descr & spt (e2=E,c1=I)
I 42 Geom & top rep (a1=W,e2=E,c1&2=I)
I 43 Repres specialization (e2=E,c1=I,c2=F)
I 44 Product struct confg (e2=E,c1=I)
I 45 Materials (c1=I)

I 46 Visual presentation (c1=I)
I 47 Tolerances
X 48 Form features
I 49 Process structure & properties
C 50 Mathematical constructs

APPLICATION-INTERPRETED CONSTRUCTS

F 501 Edge-based wireframe
F 502 Shell-based wireframe
F 503 Geom-bounded 2D wireframe
F 504 Draughting annotation
F 505 Drawing structure & admin.
I 506 Draughting elements
E 507 Geom-bounded surface
E 508 Non-manifold surface
E 509 Manifold surface
I 510 Geom-bounded wireframe

F 511 Topological-bounded surface
I 512 Faceted B-representation
F 513 Elementary B-rep
I 514 Advanced B-rep
I 515 Constructive solid geometry
X 516 Mechanical-design context
F 517 Mech-design geom presentation
C 518 Mech-design shaded presentation
F 519 Geometric tolerances
I 520 Assoc draughting elements

IMPLEMENTATION METHODS

I 21 Clear-text encoding exch str (c1=I,e2=O)
I 22 Standard data access interface
I 23 C++ language binding (to #22)
E 24 C language. binding (to #22)

X 25 FORTRAN language binding (to #22)
W 26 IDL language binding (to #22)
C 27 JAVA language binding (to #22)
W 28 XML rep for EXPRESS-driven data
C 29 Ltwt Java binding (to #22)

CONFORMANCE TESTING METHODOLOGY & FRAMEWORK

I 31 General concepts
I 32 Requirements on testing labs and clients
X 33 Structure and use of abstract test suites
E 34 Abstract test methods for Part 21 impl.
W 35 Abstract test methods for Part 22 impl. (Approved for new scope)

Legend: Part Status (E, F, I safe to implement)
0=O=Preliminary Stage (Proposal-->appr for NP ballot)
10=A =Proposal Stage (NP ballot circ-->NP approval)
20=W=Preparatory Stage (Wkg Draft devel.-->CD regis)
30=C =Committee Stage (CD circulation-->DIS regis)
40=E =Enquiry Stage (DIS circ.--FDIS registration)
50=F =Approval Stage (FDIS circ-->Int'l Std regis)
60=I =Publication Stage (Int'l Std approved & published)
98=X=Project withdrawn

jgnell, 89-Oct 23; **rev. 00-06-08**. Origin: ISO 10303 Editing Committee. On-line: http://www.nist.gov/sc5/soap/

STEP on a Page provides a graphic summary of the progress of STEP, Standard for the Exchange of Product Model Data, the familiar name for ISO 10303. ISO TC184 SC4, Industrial-Automation Systems and Integration/Industrial Data develops the STEP standard.

Status of STEP Parts

Every part shown in the STEP on a Page has its status shown beside it. The status designators vary from "O" (the ISO preliminary stage) to "I" (International Standard--the most advanced stage of standards development and acceptance). Parts designated as "E, F" (levels of Draft International Standard) and "I" are considered advanced enough to allow software vendors to prepare implementations. The legend at the bottom of the page lists the corresponding ISO-project stage numbers next to the letter code.

Architecture of STEP

STEP on a Page attempts to show the STEP architecture by grouping the STEP parts into five main categories: description methods, implementation and conformance methodology, integrated-information resources, abstract-test suites, and application protocols.

Description Methods

From an architectural perspective, the description methods group forms the underpinning of the STEP standard. This includes part 1, Overview, which also contains definitions that are universal to the STEP. Also in that group, part 11, EXPRESS Language Reference Manual, describes the data-modeling language that is employed in STEP. Parts in the descriptive-methods group are numbered from 1 to 19.

Implementation & Conformance

The STEP implementation-methods group, the 20s series, describes the mapping from STEP formal specifications to a representation used to implement STEP.

The conformance-testing-methodology-framework group, the 30s series, provides information on methods to test software-product conformance to the STEP standard, guidance for creating abstract-test suites, and the responsibilities of testing laboratories. The diagram shows that part 31, which describes the methodology to perform conformance testing, has been approved as an international standard. The STEP standard is unique in that it places a very high emphasis on testing, and actually includes these methods in the standard itself.

Integrated-Information Resources

At the next level is the integrated-information-resources group, the parts that contain the actual STEP data models. These data models can be considered the building blocks of STEP. Categories of integrated-information resources are generic resources, application resources, and application-interpreted constructs, and application modules. Integrated-generic resources are generic entities that are used as needed by application protocols (APs below). Parts within generic resources are numbered in the 40s and are used across the entire spectrum of STEP APs. The integrated-application resources contain entities that have slightly more context than the generic entities. The parts in the integrated-application resources are numbered in the 100s. Because entities in the integrated-resources group are shareable across the application protocols that need them, they can help AP integration and interoperability.

The 500 series are application-interpreted constructs, AICs. These are reusable groups of information-resource entities that make it easier to express identical semantics in more than one AP.

The AIC capability is extended to reusable groups of functional information requirements of applications. The functional groups have been associated with groups of integrated-generic resources. These are the application modules that comprise the 1000 series of parts, and they offer an opportunity to represent functional capability in multiple APs with a lower standards-development cost.

Abstract-Test Suites

The 300 series of parts, abstract-test suites, consists of test data and criteria that are used to assess the conformance of a STEP software product to the associated AP. SC4 requires that every AP contain or be associated with an abstract-test suite. The numbers assigned to ATSs exceed the AP numbers by exactly 100. Therefore, ATS 303 applies to AP203. On the graphic, the ATS status is shown in parentheses following the AP name.

Application Protocols

At the top level of the STEP hierarchy are the more complex data models used to describe specific product-data applications. These parts are known as application protocols and describe not only what data is to be used in describing a product, but also how the data is to be used in the model. The APs use the integrated-information resources in well-defined combinations and configurations to represent a particular data model of some phase of product life. APs are numbered in the 200s. APs currently in use are the Explicit Draughting AP 201 and the Configuration Controlled Design AP 203.

ooOOoo

STEP on a Page was conceived and implemented by Jim Nell, National Institute of Standards and Technology. 99-November-04

2.2 Existing/Active STEP Application Protocols

The following list includes STEP Application Protocols that are active.

AP201	Explicit Draughting
AP202	Associative Draughting
AP203	Configuration Controlled 3D Designs of Mechanical Parts and Assemblies
AP207	Sheet Metal Die Planning and Design
AP209	Composite and Metallic Structural Analysis & Related Design
AP210	Electronic Assembly, Interconnection and Exchange
AP212	Electrotechnical Design and Installation
AP213	Numerical Control Process Plans for Machined Parts
AP214	Core Data for Automotive Mechanical Design Processes
AP215	Ship Arrangement
AP216	Ship Moulded Forms
AP217	Ship Piping
AP218	Ship Structures
AP219	Manage Dimensional Inspection of Solid Parts or Assemblies
AP220	Process Planning, Manufacturing, Assembly of Layered Electrical Products
AP221	Functional Data and Their Schematic Representation for Process Plants
AP223	Exchange of Design and Manufacturing Product Information for Cast Parts
AP224	Mechanical Product Definition for Process Planning Using Machining Features
AP225	Building Elements Using Explicit Shape Representation
AP226	Ship Mechanical Systems
AP227	Plant Spatial Configuration
AP230	Building Structural Frame: Steelwork
AP231	Process Engineering Data --- Process Design and Process Specifications of Major Equipment
AP232	Technical Data Packaging Core Information and Exchange
AP233	Systems Engineering Data Representation
AP234	Ship Operational Logs, Records, and Messages
AP235	Materials Information for the Design and Verification of Products
AP236	Furniture Product Data and Project Data

See the PDES, Inc. public web site: http://pdesinc.aticopr.org/whatsnew/all_aps.html for "user friendly" graphics describing most of the STEP AP's individually "on a page".

The following table identifies the stages in the ISO Standardization Process. The process of reaching international consensus on a standard can be and often is very arduous. STEP Application Protocol development, from the initial proposal for a new project (the Preliminary Work Item) to the publication of the International Standard, has taken five (5) or more years to complete.

PDES, Inc., along with other STEP organizations worldwide, has put forth an initiative to develop STEP Application Modules (AM's) that are domain, or even complete AP, building blocks. The initial set of AM's (see pp. 17-18) have been approved (April 2000) as ISO Technical Specifications (TS). This effort is aimed at significantly speeding up the ISO standardization process. The AM initiative has widespread support, particularly from the user community.

2.3 International Harmonized Stage Codes

STAGE	SUBSTAGE						
	00	20	60		90	Decision	
	Registration	Start of Main Action	Completion of Main Action	92 Repeat of Earlier Phase	93 Repeat Current Phase	98 Abandon	99 Proceed
00 Preliminary Stage	00.00 Proposal for new project received	00.20 Proposal for new project under review	00.60 Review summary circulated			00.98 Proposal for new project abandoned	00.99 Approval to ballot proposal for new project
10 Proposal Stage	10.00 Proposal for new project registered	10.20 New Project ballot initiated *4 months*	10.60 Voting summary circulated	10.92 Proposal returned to submitter for further definition		10.98 New project rejected	10.99 New project approved
20 Preparatory Stage	20.00 New project registered in TC/SC work program	20.20 Working Draft (WD) study initiated	20.60 Comments summary circulated			20.98 Project deleted	20.99 WD approved for registration as CD
30 Committee Stage	30.00 Committee Draft (CD) registered	30.20 CD study/ballot initiated *4 months-1st 3 months-2nd+*	30.60 Comments/ voting summary circulated	30.92 CD referred back to working group		30.98 Project deleted	30.99 CD approved for registration as DIS
40 Enquiry Stage	40.00 DIS registered	40.20 DIS ballot initiated *5 months*	40.60 Voting summary dispatched	40.92 Full report circulated: DIS referred back to TC or SC	40.93 Full report circulated: decision for new DIS ballot	40.98 Project deleted	40.99 Full report circulated: DIS approved for registration as FDIS
50 Approval Stage	50.00 FDIS registered for formal approval	50.20 FDIS ballot initiated: *2 months.* Proof sent to secretariat	50.60 Voting summary dispatched. Proof returned by secretariat	50.92 FDIS referred back to TC or SC		50.98 Project deleted	50.99 FDIS approved for publication
60 Publication Stage	60.00 International Standard under publication		60.60 International Standard published				
90 Review Stage		90.20 International Standard under periodical review	90.60 Review summary dispatched	90.92 International Standard to be revised	90.93 Internation al Standard confirmed		90.99 Withdrawal of International Standard proposed by TC or SC
95 Withdrawal Stage		95.20 Withdrawal ballot initiated	95.60 Voting summary dispatched	95.92 Decision not to withdraw International Standard			95.99 Withdrawal of International Standard

2.4 Summary of Application Protocols with IS Status & Selected Other "Soon to be IS" APs

The table below identifies those STEP Application Protocols that have achieved International Standard Status and have been published. Note that only AP201 and AP203 were part of the initial release of STEP in 1994. AP202 did not achieve IS status until late in 1996. AP's 207, 224 and 225 were just published late in 1999. It should also be noted that there are 6 additional STEP Application Protocols that are expected to be registered and to be published as International Standards in 2000. This is certainly an indication that STEP development is reaching a point at which numerous STEP Standards are reaching closure and stability. This can also be regarded as an opportune point in time for CAD/CAM Vendors to expand their implementation coverage.

Also included in the table below is an indication of the number of conformance classes (cc) associated with each AP. Conformance classes are subsets of an AP that can be implemented "meaningfully" within that application domain without having to implement all aspects of the AP. Implementation of selected conformance classes can be seen in those AP's that have been commercially implemented to date (viz., AP's 203 and 214).

As an engineering user, it will be important to know what conformance classes of an AP have been implemented. It is not enough to indicate that a Vendor has a STEP or an APxxx translator. The engineering user will need to know what conformance classes of APxxx have been implemented and to understand the coverage of those conformance classes. As examples: Very few Vendors who claim to have an AP203 translator have implemented cc5; most have implemented cc's 2, 4 & 6 with a "minimal (but acceptable, by consensus) subset of cc1. Vendors who claim to have an AP214 translator have only implemented cc1 and/or cc2 which are essentially identical to AP203 geometry/topology with a somewhat different set of configuration management data. (Note: AP214 has not yet reached IS status, but cc's 1 & 2 are regarded as stable, and hence acceptable for commercial implementation.) Note further that AP214 has 18 conformance classes; these 18 conformance classes cover essentially the entire spectrum of automotive design. It is misleading, at this point, for Vendors to claim that they have implemented AP214 without qualifying that statement with the conformance classes that have been implemented. There are currently no commercially available AP214 translators that address other than the AP203 "look alike" conformance classes (i.e., AP214 cc's 1 & 2).

In a section that follows this table, the scope is given for each of the AP's that have been published as ISO 10303 standards and those that are considered "soon to be IS". The conformance classes associated with each of these AP's are also provided. The intention here is to provide the engineering user with a view of the robustness of the STEP AP's and the potential usefulness of implementations of the associated conformance classes. As will be noted later, in the final analysis, it will be the engineering user who will drive the Vendor implementations of STEP AP conformance classes.

Application Protocol	Current Status	Conformance Classes	Comments
AP201	IS - 1994, (60.60/90.93) Reconfirmed-1999	1	No ATS
AP202	IS - 1996 (60.60)	10	ATS302 Exists, But Not Published (Draft)
AP203	IS - 1994, (60.60/90.93) Reconfirmed-1999	12	ATS303 Exists, But Not Published (Draft)
AP207	IS - 1999 (60.60)	14	ATS307 Published - 2000
AP224	IS - 1999 (60.60)	1	ATS324 Published - 1999
AP225	IS - 1999 (60.60)	14	ATS325 Being Balloted
**************	"Soon To Be IS"	****************	
AP209	DIS Ballot Complete - 2000 (40.60)	10	No Negative Ballots, FDIS Ballot Not Required, Comment Resolution & ATS Required
AP210	DIS Ballot Complete - 1999, (40.60) Joint ISO/IEC	30	No Negative Ballots, FDIS Ballot Not Required, Comment Resolution & ATS Required
AP212	DIS Ballot Complete - 1999, (40.60) Joint ISO/IEC	4	Comment Resolution & ATS Required
AP213	DIS Ballot Complete - 1997 (40.60)	6	FDIS Ballot Required, ATS Required
AP214	DIS Ballot Complete - 1999 (40.60)	20	FDIS Ballot Required, Comment Resolution Required, ATS314 Being Balloted
AP227	DIS Ballot Complete - 1998 (40.92)	4	FDIS Ballot Required, ATS Required
**************	"High Profile AP"	****************	
AP232	CD --- DIS Ballot in 2Q2000 (30.60)	14	ATS Required

Acronym/Abbreviation Key:

AP Application Protocol
ATS Abstract Test Suite
CD Committee Draft
DIS Draft International Standard
FDIS Final Draft International Standard
IEC International Electrotechnical Commission
IS International Standard
ISO International Organisation for Standardisation

A concept that was created within the STEP development process was that of the Application Interpreted Construct (AIC) which could be referenced by multiple AP's and, thereby, reduce the volume of the AP documents and assure consistency among the AP's referencing the AIC's.

Another concept that has been established to assist and accelerate STEP development and implementation is that of the Application Module (AM). The intent of AM's is to identify and develop modules that have commonality among numerous application domains. Existing AP's could be modularized and new AP's could be built using AM's. In addition, AM's could be used to extend existing AP's as has been done with AP203 implementations that are being prototyped and tested in the CAx - Implementors Forum (see below). As stated previously, the AM process portends to significantly reduce STEP development timelines.

STEP On A Page (SOAP), above, briefly defines and identifies AIC's and AM's.

The status of STEP Application Interpreted Construct (AIC) as reported at the ISO TC184/SC4 Working Group Meetings in Melbourne, Australia (13-18 February 2000) is that AIC's 501 - 515, 517, 519, 520 have all achieved International Standard (IS) status. AIC518 has been submitted for its Draft International Standard Ballot (DIS). Note: AIC516 was cancelled earlier. (http://www5.50megs.com/wg3/wg3n892.htm#Appendix_B)

The AIC's are reiterated below for reference

501 - Edge-based wireframe
502 - Shell-based wireframe
503 - Geometrically Bounded 2D wireframe
504 - Draughting annotation
505 - Drawing structure and administration
506 - Draughting elements
507 - Geometrically bounded surface
508 - Non-manifold surface
509 - Manifold surface
510 - Geometrically bounded wireframe
511 - Topologically bounded surface
512 - Faceted boundary representation
513 - Elementary boundary representation
514 - Advanced boundary representation
515 - Constructive solid geometry
517 - Mechanical design geometric presentation
518 - Mechanical design shaded presentation
519 - Geometric tolerances
520 - Associative draughting elements

The initial set of nine (9) Application Modules (AM) (AMs 1001-1009) were approved as Technical Specifications (TS) in April 2000. (http://www.nist.gov/sc4/nwi_pwi/nwi/step/sal_mods/)

This initial set of AM's is listed below:

1001 - Application module: Appearance assignment
1002 - Application Module: Colour
1003 - Application module: Curve appearance
1004 - Application module: Elemental shape
1005 - Application module: Elemental topological shape.
1006 - Application module: Foundation representation.
1007 - Application module: General surface appearance.
1008 - Application Module: Layer assignment
1009 - Application Module: Shape appearance and layers

For more information on the concept and architecture of STEP Application Module Development, visit the following web site: http://wg10step.aticorp.org/Modules/index.htm

It can be noted that selective pilot/prototype testing of modular extensions of AP203 with the Colours & Layers, Associative Text, and Geometric Validation Properties modules is being done in the Joint PDES, Inc./ProSTEP CAx - Implementors Forum (CAx-IF).

Recommended Practices Guides (RPGs) exist for these modules and several others and can be found on the PDES, Inc. public web site.

"PDES, Inc. Developed Recommended Practices Documents:
http://pdesinc.aticorp.org/rec_prac.html

AP 203 Recommended Practices
AP 209 Recommended Practices
AP 210 Concept of Operations

PDES, Inc. and ProSTEP Developed Recommended Practices Documents:

PDM Schema Usage Guide
3-D Associative Text Recommended Practices
Recommended Practices for Dimensions and Dimensional Tolerances
Recommended Practices for Form Features: Round Hole, Thread and Compound Features
Recommended Practices for Colors and Layers
Recommended Practices for Model Viewing
Recommended Practices for Geometric Validation Properties"

Other Recommended Practices Guides (RPG's) are in preparation, including AP227 and AP232.

In the next section, the scope is given for each of the AP's that have been published as ISO 10303 standards and those that are considered "soon to be IS". The conformance classes associated with each of these AP's are also provided. The intention here is to provide the engineering user with a view of the robustness of the STEP AP's and the potential usefulness of implementations of the associated conformance classes. It is the user community who must drive the Vendor implementations of STEP AP conformance classes.

2.5 Application Protocol (AP) Capabilities

(AP Scopes and their Conformance Classes)
(What they cover and what they don't)

SCOPE and Conformance Classes for STEP APs:

These scope descriptions are taken from the SC4 Project Management Database that was last updated on SOLIS on April 1999. The conformance class descriptions are taken from Clause 6 of the International Standard (IS), Draft International Standard (DIS), or Committee Draft (CD) document as appropriate for the current stage of the AP. The AP's which have achieved IS status are listed first.

It should be noted that a conformance class of an ISO 10303 Application Protocol specifies a meaningful part of the AP, **all** of which must be supported by an implementation. Conformance to a particular conformance class requires that all AIM entities, types, and associated constraints defined as part of that class be supported. Conformance to a particular conformance class requires conformance to each conformance class included in that class. Conformance to a particular conformance class requires that all Application Resource Model (ARM) constraints for the Units of Functionality (UoF's) implemented by this class be supported. (Clause 6 of the Standard spells out the details of each conformance class.) More detailed descriptions of the conformance classes for AP's 210, 212, 214 & 227 can be found in the Appendix.

This section is intended to give the engineering user insight into the coverage of the specific AP to assist in determining what an implementation of some or all of the conformance classes of this AP can provide to this user. If more detail is needed, the reader is referred to the Appendix and/or Clause 6 of the Standard itself.

International Standards:

2.5.1 AP201: Explicit Draughting

"This part of ISO 10303 is applicable to the inter-organization exchange of computer-interpretable drawing information and product definition data.

The following are **within** the scope of this part of ISO 10303:

- The representation of drawings for the purpose of exchange, especially for mechanical engineering, architectural engineering, and construction applications;
- The representation of the real size of a product depicted in a drawing to enable use by applications where true geometric equivalence is required;
  (The representation of the shape of the product is required to support not only visual equivalence of exchanged drawings but also where true geometric equivalence is required by the receiving system. Such uses include the calculations of distances or areas and the generation of numerical control tool paths.)
- The representation of a drawing that depicts any phase of the design;
- The representation of individual drawing revisions;
- The representation of the two-dimensional draughting shape model depicting the product shape and the Transformations used for the generation of the drawing views;

- The presentation of non-shape product definition data depicted in a drawing by tow-dimensional annotations;
- The hierarchical structure of drawings, drawing sheets, and views of the draughting shape model;
- The mechanisms for the grouping of the elements depicted on a drawing;
- The administrative data used for the purpose of drawing management;
- The administrative data identifying the product versions being documented by the drawing.

The following are **outside** the scope of this part of ISO 10303:

- The representation of the shape of a product using three-dimensional geometry;
- The representation of the shape of a product that is not depicted in a drawing;
- The representation of drawings that are not related to a product;
- The exchange of drawing history;
- The definition of annotation in three-dimensional coordinate systems;
- The presentation of dimensions and annotation that are associated to viewed geometry and annotation;
- A computer-interpretable bill of material structure except as conveyed by annotation on the drawing;
- Strict enforcement of draughting standards;
- Drawings containing non-displayable attribute data other than that required as administrative data (e.g., density, mass, or moment of inertia);
- The automatic generation of drawings including views, dimensions, and annotation.
- The exchange of data used exclusively for the creation of paper or hardcopy versions of the drawing (e.g., pen designations, plot scale, or plot color specifications)."

AP201 is a single Conformance Class.

cc: Explicit Draughting

2.5.2 AP202: Associative Draughting

"This part of ISO 10303 provides for the inter-organization exchange of computer-interpretable drawing information and associated product definition data.

The following are **within** the scope of this part of ISO 10303:

- The structures for representing drawings for the purpose of exchange, suitable for mechanical engineering and Architecture, Engineering, Construction (AEC) applications;
- The structures for representing a drawing that depicts any phase of the life cycle of a product;
- The structures for representing individual drawing revisions;
- The structures for representing the two-dimensional or three-dimensional product shape;
- The structures for representing the transformations of the shape model used for the generation of the drawing views;
- The hierarchical structure of drawings, drawing sheets, and views of the draughting shape model;

- The presentation of non-shape product definition data depicted in a drawing by two-dimensional annotation or planar annotation defined in a three-dimensional coordinate space;
- Mechanisms for the grouping of the elements depicted on a drawing;
- The administrative data used for the purpose of drawing management;
- The administrative data identifying the product versions being documented by the drawing;
- The structures for representing associations between dimensions or draughting callouts and their respective target product shape geometry or annotation;
- The structures for representing associations between the boundaries of a fill area and the product shape geometry or annotation from which they are derived;
- Seven classes of draughting shape models used to represent product shape which include advanced boundary representation, faceted boundary representation, elementary boundary representation, manifold surfaces with topology, surface or wireframe geometry without topology, wireframe geometry with topology, and elementary curve sets;
- The presentation of dimensions and annotation that may be, but need not be, associated with viewed geometry or annotation.

The following are **outside** the scope of this part of ISO 10303:

- A draughting shape model that is not depicted in a drawing nor used as a constituent of another draughting shape model;
- The structures for representing drawings that are not related to a product;
- The structures for defining the relationship between multiple drawings;

  Drawings could be related to document the assembly structure of a part or define the history between multiple versions of the same drawing.

- Non-planar annotation defined in a three-dimensional coordinate space;
- A bill of material presented on the drawing by annotation where the information is interpretable to a computer as a bill of materials;
- Enforcement of conventions and rules found in draughting standards;

  This part of ISO 10303 supports the use of draughting standards but does not redefine them.
- The exchange of non-displayable attribute data other than that required as administrative data (e.g., density, mass, or moment inertia);
- The automatic generation of drawings including views, dimensions, and annotations;
- The exchange of data used exclusively for the creation of paper or hard copy versions of the drawing (e.g., pen designations, plot scale, or plot colour specifications);
- The presentation of the shape of a product in a two-dimensional view using light sources and shading;
- The association between geometric tolerances and related geometric elements;

  A geometric tolerance as described above is a combination of geometric characteristics symbols, tolerance values, and datum references, where applicable, to express the permissible variation from the theoretically exact size, profile, orientation, or location of a feature or datum target. Each of the three possible components, geometric characteristic symbols, tolerance values, and datum references are computer-identifiable but not computer-interpretable and, therefore, cannot be associated to geometric elements.

- The association between computer-recognizable limit dimensions and shape geometry or annotation."

AP202 has 10 Conformance Classes:

The conformance classes are characterized as follows:

cc 1: Administration, annotation, data organization (layers, groups), and drawing structure presentation (colors, fonts) without shape
cc 2: cc 1 and elementary 2D geometrically bounded wireframe
cc 3: cc 1 and all 2D geometrically bounded wireframe
cc 4: cc 1 and 2D topological wireframe
cc 5: cc 1 and 3D geometrically bounded wireframe and/or surfaces
cc 6: cc 1 and 3D topological wireframe
cc 7: cc 1 and faceted B-Rep
cc 8: cc 1 and elementary B-Rep
cc 9: cc 1 and advanced B-Rep
cc 10: cc 1 and manifold surface models with topology

2.5.3 AP203: Configuration Controlled 3D Designs of Mechanical Parts and Assemblies

" The following are **<u>within</u>** the scope of this part of ISO 10303:

- Products that are mechanical parts and assemblies;
- Product definition data and configuration control data pertaining to the design phase of a product's development;
- The change of a design and data related to the documentation of the change process;
- Five types of shape representations of a part that include wireframe and surface without topology, wireframe geometry with topology, manifold surfaces with topology, faceted boundary representation, and boundary representation;
- Alternate representation of the data by different disciplines during the design phase of a product's life cycle;
- Identification of government, industry, company or other specifications for design, process, surface finish, and materials which are specified by a designer as being applicable to the design of the product;
- The identification of government, industry, company, or other standard parts for the purpose of their inclusion in a product's design;
- Data that are necessary for the tracking of a design's release;
- Data that are necessary to track the approval of a design; a design aspect, or a configuration control aspect of a product;
- Data that identify the supplier of either the product or the design and, where required by an organization, qualification information for the supplier;
- If a part is being designed under a contract, the identification of , and reference to, that contract under which a design is developed;

- The identification of the security classification of a single part or a part when it is a component in an assembly;
- Data that is used in, or results from, the analysis or test of a design which is used as evidence for consideration of a change to a design.

The following are **outside** the scope of part of ISO 10303:
- Data that is used in, or results from, the analysis or test of a design that is not used as evidence for consideration of a change to a design;
- Data that results in changes to the design during the initial design evolution prior to its release;
- Product definition data and configuration control data pertaining to any life cycle phase of a product's development other than design;
- The business data for the management of a design project;
- Alternate representations of the data by different disciplines outside of the design phase (e.g., manufacturing);
- The use of constructive solid geometry for the representation of objects;
- Data that pertains to the visual presentation of any of the shape or configuration control data."

2nd Edition - No Change in Scope - Will be Modularized

AP203 has 12 Conformance Classes:

The conformance classes are characterized as follows:

cc 1a, b: Configuration controlled-design information without shape (cc 1a is a specified "product identification" subset of cc 1b)
cc 2a, b: cc 1a, b and 3D geometrically bounded wireframe and/or surface models
cc 3a, b: cc 1a, b and 3D wireframe models with topology
cc 4a, b: cc 1a, b and manifold surface models with topology
cc 5a, b: cc 1a, b and faceted B-Rep
cc 6a, b: cc 1a, b and advanced B-Rep

2.5.4 AP207: Sheet Metal Die Planning and Design

"This part of ISO 10303 specifies the use of the integrated resources necessary for the scope and information requirements for exchange of information between contractors and suppliers to enable the eventual manufacture of sheet metal dies used in the production process of sheet metal parts.

The following are **within** the scope of this part of ISO 10303:
- Types of product supported: (This list describes the types of product for which data is in scope. The products themselves are not in scope, because they are not data.)
  (1) Sheet metal part design data (Sheet metal part designs may be for sheet metal parts intended for the exterior of a product, those intended for the interior of a product, those intended to be in view on the final product, or those intended to support loads or maintain structure of a product. Sheet metal part designs may also be for sheet metal parts that are products in themselves.);

(2) Sheet metal die design data, including die face design and die structure design, for an individual die against which sheet metal is formed by processes that do not involve a mating die;
(3) Sheet metal die set design data, including die face design and die structure design, for die sets used in a stamping press machine to manufacture sheet metal parts;
(4) Sheet metal part manufacture description data.

- Types of product data supported:
  (1) Design data for materials, sheet metal in-process parts, sheet metal parts, die components, individual dies, and dies sets;
  (2) Process data for sheet metal part manufacture;
  (3) Change and schedule data for design of product definition data and manufacture description data;
  (4) Data ownership, generating system information, and exchange history surrounding product definition data and manufacture description data;
  (5) The identification of externally designed parts and purchased items;
  (6) Design constraints on dies;
  (7) Wireframe, surface, and solid geometry;
  (8) Data describing the relative position of materials and in-process sheet metal parts to the die or dies that will further form them;
  (9) Composition of materials, sheet metal parts, and die components;
  (10) Properties associated with materials or with collections of geometric representations, such as
  hardness, porosity, method of manufacture, and function.

- Stages in the product life cycle supported are data at any stage of completion that describes:
  (1) Materials;
  (2) Sheet metal in-process parts and sheet metal parts;
  (3) Die components, individual dies, and die sets;
  (4) Sheet metal part manufacture description data;
  (5) Change and schedule data for design of product definition data and manufacture description data.

- The supported exchange scenarios from contractor to supplier are as follows:
  (1) Requirements to enable the supplier to create a sheet metal part processing plan for the contractor, such as the sheet metal part design, available presses and plants, and plant and press constraints;
  (2) Requirements to enable the supplier to create a die design for the contractor, such as the sheet metal part design and the sheet metal part processing plan. This design may be for the die face, or for the die structure, or for both;
  (3) Exchanges wherein the contractor and supplier are divisions of the same company;
  (4) Exchanges wherein the contractor and supplier are different companies.

- The supported exchange scenarios from supplier to contractor are as follows:
  (1) As part process plan or any portion thereof;
  (2) A complete die design or any portion thereof;
  (3) A die face design or any portion thereof;
  (4) A die structure design or any portion therefore;

(5) A change request;
(6) Exchanges wherein the contractor and supplier are divisions of the same company;
(7) Exchanges wherein the contractor and supplier are different companies.

The following are **outside** the scope of this part of ISO 10303:

- ♦ Parts that are not made of sheet metal or are not manufactured by a process involving the use of a die or dies;
- ♦ Sheet metal parts that are manufactured by explosive forming or forging;
- ♦ The design of devices used to stretch sheet metal over single convex dies, or the rubber bladder or sheet used in hydroforming or trap rubber forming to force sheet metal into a single concave die;
- ♦ Parametric or variational geometry models of sheet metal parts, dies, or die components;
- ♦ Engineering analysis data of any kind;
- ♦ Financial data of any kind;
- ♦ Manufacturing process data for sheet metal dies;
- ♦ Any exchange uses of data in order to:
  - ⇒ enable the initial design of sheet metal parts;
  - ⇒ enable the design of checking fixtures;
  - ⇒ enable the manufacture of the die.
- ♦ Data related to production runs of sheet metal parts."

AP207 has 14 Conformance Classes:

The conformance classes are characterized as follows:

cc 1: Product management (PM) and identification information without shape
cc 2: cc 1 and sheet metal part process plan data without shape
cc 3: cc 1 and shapes represented by topologically bounded wireframe models
cc 4: cc 1 and shapes represented by geometrically bounded wireframe and surface models
cc 5: cc 1 and shapes represented by manifold surface models with topology
cc 6: cc 1 and shapes represented by faceted B-Rep
cc 7: cc 1 and shapes represented by advanced B-Rep
cc 8: cc 1 and shapes represented by constructive solid geometry (CSG)
cc 9: cc 2 and shapes represented by topologically bounded wireframe models
cc 10: cc 2 and shapes represented by geometrically bounded wireframe and surface models
cc 11: cc 2 and shapes represented by manifold surface models with topology
cc 12: cc 2 and shapes represented by faceted B-Rep
cc 13: cc 2 and shapes represented by advanced B-Rep
cc 14: cc 2 and shapes represented by constructive solid geometry (CSG)

2.5.5 AP224: Mechanical Product Definition for Process Planning Using Machining Features

" This Part of ISO 10303 specifies the information needed to define product data necessary for manufacturing single piece mechanical parts. The product data is based on existing part designs that have their shapes represented by machining features. This part supports digital representation for computer integrated manufacturing.

The following are **within** the scope of this Part of ISO 10303:

- A single mechanical part manufactured by machining processes;
- Products that are to be manufactured by either milling or turning processes;
- Machining features for defining shapes necessary for manufacturing (Note: The machining feature set is defined in this part of ISO 10303);
- Machining features definition items necessary for creating machining form features;
- Customer order administrative data to track receipt of an order for a part to the shop floor, but not including tracking of the order on the shop floor;
- Approval data to authorize the manufacture of a part;
- Requisition administrative data to identify requirements and track the status of materials and equipment needed to manufacture a part;
- Identification of the status of a part work order;
- Track the state of raw stock for documenting the manufacturing history of a part;
- Track the design exception notice of a part (NOTE: The design exception notice relates to discrepancies in the machining features used to describe a part's shape);

The following are **outside** the scope of this Part of ISO 10303:

- Results from process planning;
- Representation of assemblies;
- Representation of composite material parts;
- Representation of sheet metal parts;
- Representation of part pedigree;
- Design features of a part;
- Schedule for completing a work order through the manufacturing process;
- Configuration control."

2nd Edition -

The scope is extended to address the Representation of Manufactured Assemblies.
The content of AP224 is expanded to include:

- several new machining features (cutout, recess, rib top, and shape profile),
- the enhancement of several existing machining features (planar face, n-gon profile, n-gon base shape, and the addition of a rectangular boss subtype),
- the ability to group features.

Features, dimensions, and tolerances are harmonized with AP214.

AP224 has a single Conformance Class:

cc: Feature based process planning and shape represented by advanced B-Rep.

2.5.6 AP226: Building Elements Using Explicit Shape Representation

"This part of ISO 10303 specifies the building element shape, property, and spatial arrangement information requirements for building elements. Such information can be used at all stages of the life cycle of a building, including the design process, construction, and maintenance; the purpose is to enable software application systems in all building and construction industry sectors to exchange building element shape, property, and spatial arrangement information. Building element shape, property, and spatial arrangement information requirements specified in this part support the following activities:

- ⇒ concurrent design processes or building design iterations;
- ⇒ integration of building structure designs with building systems designs to enable design analysis;
- ⇒ building design visualization;
- ⇒ specifications for construction and maintenance; and
- ⇒ analysis and review. (e.g., A design analysis function combines the building structure design with building service systems designs (for systems such as heating, ventilation, and air conditioning (HVAC) and piping) to check for physical clashes of the building structural elements with piping or air conditioning elements.

The following are **within** the scope of this part of ISO 10303:

- ♦ Explicit representation of the 3D shape of building elements (The shape of the building elements are represented explicitly using boundary representation (B-rep) solid models, swept solid models, and constructive solid geometry (CSG) models.);
- ♦ The spatial arrangement of building elements that comprise the assembled building;
- ♦ Building structures that represent physically distinct buildings that are part of a single building complex;
- ♦ Non-structural elements that enclose a building or separate areas within a building;
- ♦ The shape and arrangement of equipment and service elements that provide services to a building;
- ♦ The shape and arrangement of fixtures in a building;
- ♦ Service elements include items such as plumbing, ductwork, and conduits. Equipment includes items such as compressors, furnaces, or water heaters.
- ♦ Fixtures include items such as furniture and installed items like doorknobs.
- ♦ Specification of spaces and levels (Spaces include rooms, accesses, and hallways. Levels include concepts such as floors and mezzanines of a building);
- ♦ The shape of the site on which the building will be erected;
- ♦ Specification of properties of building elements, including material composition;
- ♦ Specification of classification information (Elements may be classified for reasons which include cost analysis, acoustics, or safety);
- ♦ Association of properties and classification information to building elements;
- ♦ Changes to building element shape, property, and spatial arrangement information;
- ♦ Association of approvals with building element shape, property, and spatial arrangement information;
- ♦ As-built record of the building.

The following are **outside** the scope of this part of ISO 10303:

- 2D shape representation and draughting presentation;
- The contents of building standards;
- Implicit representation of building elements through selection of standard parameters;
- Structural analysis of building structures, including loads, connections, and material properties required for analysis;
- Thermal analysis of buildings;
- The assembly process, joining methods, and detailed connectivity of building elements;
- Building maintenance history, requirements, and instructions;
- Approval, revision, versioning, and design change histories;
- Building elements without explicit shape representation;
- Bills of quantities (Note: In industries other than AEC, bills of quantities are often referred to as bills of material)."

AP225 has 14 Conformance Classes:

The three identified levels of geometric complexity are defined as follows:

- Faceted - geometric representations composed of lines and planes
- Elementary - geometric representations composed of faceted elements and the following curves and surfaces: circles, ellipses, hyperbolas, parabolas, b-spline curves, conical surface, cylindrical surface, spherical surface, and toroidal surface
- Advanced - geometric representation composed of elemetary elements and b-spline surfaces

The conformance classes are characterized as follows:

cc 1: Building element and component property, classification, identification, and administration information; building composition and building element spatial arrangement; single level assemblies; and building element and component shape using faceted geometric shape representations.

cc 2: Building element and component property, classification, identification, and administration information; building composition and building element spatial arrangement; single level assemblies; and building element and component shape using faceted shape representations.

Note: *The term "geometric shape representation encompasses both geometric sets and b-reps. Omission of the word "geometric" implies that in addition to geometric sets and b-reps, CSG representations are also included.*

cc 3: Building element and component property, classification, identification, and administration information; building composition and building element spatial arrangement; single level assemblies; building site shape; and building element and component shape using faceted and elementary geometric shape representations.

cc 4: Building element and component property, classification, identification, and administration information; building composition and building element spatial arrangement; single level assemblies; building site shape; and building element and component shape using faceted and elementary shape representations.

cc 5: Building element and component property, classification, identification, and administration information; building composition and building element spatial arrangement; single level assemblies; building site shape; and building element and component shape using faceted, elementary , and advanced geometric shape representations.

cc 6: Same as cc 1 except that it includes multi-level assemblies.
cc 7: Same as cc 2 except that it includes multi-level assemblies.
cc 8: Same as cc 3 except that it includes multi-level assemblies.
cc 9: Same as cc 4 except that it includes multi-level assemblies.
cc 10: Same as cc 5 except that it includes multi-level assemblies.
cc 11: Building composition and arrangement of spaces; spaces and space property, classification, identification, and administrative information; and space shape using faceted and ground face space representations.
cc 12: Building composition and arrangement of spaces; spaces and space property, classification, identification, and administrative information; and space shape using faceted, ground face, and elementary space representations.
cc 13: Building composition and arrangement of spaces; spaces and space property, classification, identification, and administrative information; and space shape using faceted, ground face, elementary, and advanced space representations.
cc 14: Building complex and surrounding grounds shape and position.

2.6 SCOPE (Selected "Soon To Be" International Standards):

2.6.1 AP209: Composite and Metallic Structural Analysis and Related Design

"This part of ISO 10303 specifies computer-interpretable composite and metallic structural product definition including their shape, their associated finite element analysis (FEA) model and analysis results, and material properties.

The following are **within** the scope of this part of ISO 10303:

- the definition of composite structural parts;
- the definition of metallic structural parts;
- linear statics finite element analysis;
- the product definition and configuration control information pertaining to the design through analysis stages of a product's development;
- the information relating the part to the adjoining components in an assembly by either explicit or external reference;
- the 2D and 3D models depicting the product shape;
- the five types of geometric and topologic model representations which include:
  (1) wireframe and surface without topology;
  (2) wireframe geometry with topology;
  (3) manifold surfaces with topology;
  (4) faceted boundary representation; and
  (5) advanced boundary representation.
- the representations for design and analysis disciplines and the association of the design, idealized design and finite element node shape representations;
- the association of the constituents of composite and metallic parts with the constituent shape model;

- the depiction of composite laminate tables describing the material, stacking sequence, orientation, and constituents of the composite or a portion of the composite with a defined shape;
- the identification of material specifications from internal and external sources and their properties for a specific operating environment;
- the finite element analysis model, analysis controls, and analysis results information;
- the plane stress and simple plane strain types of linear static finite element structural analyses;
- the 2D vector graphical presentation of:
  (1) finite element model maps ;
  (2) analysis output information displays upon finite element model mesh;
  (3) line drawings which document the part aspects subjected to detail analyses
- the tabular presentation of the analysis assumptions, loadings, and critical locations in finite element and detail analyses performed for the assessment of the margin of safety;
- the administrative information necessary to track the approval and configuration control of the design and analysis of a product at a point in the life cycle when approval and configuration control are necessary;
- a change to a design and an analysis, including information to identify the change, at a point in the life cycle when tracking a change is necessary;
- the identification, when required, of the contract under which a design is developed and an analyses is performed;
- the identification of the security classification of a part.

The following are **outside** the scope of this part of ISO 10303:

- the business information for the management of a design and analysis project;
- the product definition and configuration control information pertaining to any information other than that necessary for design and analysis;
- alternate representation of the information by disciplines outside of design and analysis such as manufacturing;
- the use of constructive solid geometry for the representation of the shape of the product;
- the explicit representation of a bill-of-material;
- the other types of finite element analysis beyond linear statics, such as dynamic and non-linear statics;
- the explicit graphical presentations derivable from design or analysis product representations;
- specification of filament wound structures;
- the composite fabrication process information;
- the product definition of initial or in-process part shapes.

AP209 has 10 Conformance Classes.

"…Support for a particular conformance class requires support of all the elements specified in that class.

Conformance to this part of ISO 10303 requires conformance to at least one of the primary conformance classes 7 through 10.

Classes 2 through 6 are the shape representation conformance classes that may be used for ISO 10303-209. One or more shape representation conformance classes may be selected by an implementation and combined with the primary conformance classes 7 through 10."

The conformance classes are characterized as follows:

cc 1: Support for configuration control without shape information.
cc 2: Support for Class 1 plus shapes represented by non-topological surface and wireframe.
cc 3: Support for Class 1 plus shapes represented by wireframe with topology.
cc 4: Support for Class 1 plus shapes represented by manifold surface with topology.
cc 5: Support for Class 1 plus shapes represented by faceted boundary representation.
cc 6: Support for Class 1 plus shapes represented by advanced boundary representation.
cc 7: Support for material, part composite constituents, composite constituent representation, part laminate table, and zone composite constituents and their representation.
cc 8: Support for Class 7 plus finite element analysis model and analysis report.
cc 9: Support for Classes 7 and 8, plus finite element analysis control.
cc 10: Support for Classes 7, 8 and 9, plus finite element analysis results.

2.6.2 AP210: Electronic Assembly, Interconnect and Packaging Design

"ISO 10303-210 specifies the information requirements for the design of electrical printed circuit assemblies.

The following are **within** the scope of ISO 10303-210:

- The hierarchical description of the printed circuit assembly (PCA) that identifies the functional objects that are used in the PCA composition;
- The description of the functional objects that are combinations of one or more parts or functional objects;
- The configuration management of the functional objects that are being developed concurrently;
- The configuration management of analytical models that are being developed concurrently;
- The reference to analytic models that are used to define the behavior of a part or PCA or printed circuit board (PCB);
- The description of the connection among the functional objects, packaged parts, and the requirements for physical interconnection;
- The physical layout of the PCA, including a description of the placement of the parts and their interconnections;
- The description of the bare printed circuit board, including the conductive and non-conductive layers of the board;
- The functional and physical description of parts and components, both printed and packaged including material characteristics and composition;
- The description of the requirements and constraints on the design of the PCA that assure product performance, incorporate quality, and enhance manufacturing process capabilities;
- The configuration management of PCA descriptions;

- The description of PCAs and PCBs to implement various functional domains including, but not limited to, analog, digital, video, RF, and microwave;
- The configuration management of constituent parts that are PCAs and PCBs and are being concurrently developed;
- The allocation of requirements to functional objects, physical objects, and the physical implementation;
- The allocation of requirements from functional objects to their physical implementation;
- The configuration management of documents that contain requirements;
- The association of characteristics to functional objects, parts and components;
- The identification of actual parameters for parts and functional objects;
- The identification of planned parameters for functional objects, PCAs, and PCBs.

The following are **outside** the scope of ISO 10303-210:

- The presentation of the part and the PCA descriptions;
- The process plans for the fabrication of the PCB;
- The classification and categorization of data element types;
- The process plans for the assembly of the PCA;
- The definition and interpretation of external file formats for analytic models
- The management of the process used to design a PCA;
- The management of the manufacture of the parts used by a PCA;
- The administrative procurement and cost data used by an enterprise.

AP210 has 30 Conformance Classes: (See Appendix for more detail)

The conformance classes are characterized as follows:

cc 1 - Device Functional and Physical Characterization
cc 2 - Interconnect Technology Constraints
cc 3 - Assembly Technology Constraints
cc 4 - Assembly Functional Requirements
cc 5 - Assembly Physical Requirements
cc 6 - Interconnect Functional Requirements
cc 7 - Interconnect Physical Requirements
cc 8 - Assembly Physical Design
cc 9 - Interconnect Design
cc 10 - Interconnect Design (Microwave)
cc 11 - Geometric Dimensioning and Tolerancing
cc 12 - Product Rule
cc 13 - Functional Decomposition
cc 14 - Package Functional and Physical Characterization
cc 15 - Geometrically Bounded Surface Model
cc 16 - Wireframe Model with Topology
cc 17 - Advanced Boundary Representation
cc 18 - Constructive Solid Geometry
cc 19 - Extruded Solid
cc 20 - Geometrically Bounded 2d Wireframe Model
cc 21 - Wireframe 2d Model with Topology
cc 22 - Curve 2d

cc 23 - Basic Curve 2d
cc 24 - Laminate Assembly Design
cc 25 - Connection Zone Based Model Extraction
cc 26 - Functional Specification
cc 27 - Physical Unit Physical Characterization
cc 28 - Packaged Part White Box Model
cc 29 - Printed Part Functional and Physical Characterization
cc 30 - Open Shell Model

Conformance to this part of ISO 10303 requires conformance to one of the following:

- any combination of the conformance classes 1 through 7
- conformance class 8
- any combination of the conformance classes 9, 10, 24
- any combination of the conformance classes 24 through 29
- any combination of the conformance classes 13, 14

Conformance class 12 may be used for ISO 10303-210.
Conformance classes 15 through 23, and class 30, are shape representation conformance classes that may be used for ISO 10303-210.

2.6.3 AP212: Electrotechnical Design and Installation

This Part of ISO 10303 specifies information requirements for the exchange of design information of electrotechnical plants and industrial systems.

There is no restriction whether those systems are used to equip a building, a plant, or transportation systems like cars or ships. This covers equipment for power-transmission, power-distribution, and power-generation, electrical machinery, electric light and heat, control and automation systems.

This Application protocol includes the description of the data needed for design, installation and commissioning of electrotechnical plants, and for their representation in documents, as specified in IEC 1082: Preparation of documents used in electrotechnology. That includes the hierarchical structure of products and functions, their interrelations, their connectivity and their schematic representation.

The following are **within** the scope of this Part of ISO 10303.

- The data needed to describe an electrotechnical plant throughout the phases of design, installation and delivery although those data will be used throughout the life cycle of the product;
- Data needed to describe terminals and interfaces of electrotechnical products;
- Data needed to describe the functional decomposition of an electrotechnical product;
- Data needed to describe the cabling and harnesses of devices and equipment;
- Data needed to describe cable tracks and to give the required mounting instructions;
- Data needed for the reference designation of the design's building blocks;
- Data needed to specify the pieces of information exchanged between the various parts of the design;
- Objects to furnish the design with appropriate technical data;

- Data that are necessary for the tracking of a design's release;
- Data that are necessary to track the approval of a design or a design aspect.

The following are **outside** the scope of this Part of ISO 10303.

- Data describing design changes before the initial approval (e.g. design corrections from checking);
- The business data for the management of a design project (e.g. budget, schedule);
- Data needed for the simulation and testing of a design (e.g. test patterns, behavioural models);
- The mechanical design of electric/electronic products.

AP212 has 4 Conformance Classes: (See Appendix for more detail)

The conformance classes are characterized as follows:

cc 1: Configuration controlled design information without functional aspects and installation information. (This cc describes the equipment used in an electrotechnical system and its documentation throughout all stages of the design of the system and its installation.)

cc 2: cc1 and functional aspects of the design. (This cc describes the functional aspects of an electrotechnical system throughout all stages of the design of the system and its installation.)

cc 3: cc1 and installation information. (This cc describes the spatial aspects of an electrotechnical system throughout all stages of the design of the system and its installation and its documentation.)

cc 4: The full extent of this part of ISO 10303 (i.e., cc 1 and cc 2 and cc 3) (This cc describes all aspects of an electrotechnical system throughout all stages of the design of the system and its installation.)

2.6.4 AP213: Numerical Control Process Plans for Machined Parts

This part of ISO 10303 specifies information requirements for the exchange, archival and sharing of computer-interpretable numerical control (NC) process plan information and associated product definition data.

The following are **within** the scope of this part of ISO 10303:

- Information from the planning activity that is contained in the NC process plans for machined parts;
- Work instructions for the tasks required to manufacture a part, using numerical control, which include:
  (1) references to the resource required to perform the work;
  (2) the sequences of the work instructions;
  (3) relationships of the work to the part geometry;
- references to standards and specifications declared in the process plan;
- information required to support NC programming of processes specified in the process plan (This includes product definition, administrative data, machine, tooling, and material requirements);

- Information required to support in-process inspection specified in the process plan (In-process inspection includes such tasks as using gage blocks or performing a probing operation to verify the dimensional constraints placed upon the part);
- shop floor information specified in the process plan (Shop floor information containing such items as part routing, machine setup, and part loading instructions).

The following are **outside** the scope of this part of ISO 10303:

- NC process information derived from, or required for, manufacturing preplanning activities (This includes information from activities such as factory capacity planning , scheduling, producibility analysis, and statistical process control);
- production control and scheduling analysis;
- production planning functions;
- actual execution of the process plan;
- continuous processes (Continuous process is the control of a process that requires feedback to determine new parameters such as those used in the manufacture of chemical and plating products);
- make or buy analysis activities;
- costing data;
- NC program, source programs, and specific machine tool controller codes;
- form features;
- drawing and production illustration contents;
- the process planning activity itself;
- inspection processes that require an inspection plan (Inspection processes refer to inspection that occurs outside the context of the NC machining process, such as removing the part and remounting it on a Coordinate Measuring Machine (CMM)).

AP213 has 6 Conformance Classes

The conformance classes are characterized as follows:

cc 1: NC process plan information without shape;
cc 2: cc 1 and shapes represented by non topological surface and wireframe models;
cc 3: cc 1 and shapes represented by wireframe models with topology;
cc 4: cc 1 and shapes represented by manifold surface models with topology;
cc 5: cc 1 and shapes represented by faceted b-rep;
cc 6: cc 1 and shapes represented by advanced b-rep.

cc 1 is a prerequisite for cc 2 through 6. If an implementation conforms to any of cc 2 through 6, then it shall also conform to cc 1.

2.6.5 AP214: Core Data for Automotive Mechanical Design Processes

"The AP Scope - the exchange of information between various applications which support the development process of a vehicle.

The following are **within** the scope of this part of ISO-10303:

- Products of automotive manufacturers and suppliers that include parts, assemblies of parts, tools, and assemblies of tools. The parts include the constituents of the car body, power train, chassis, and interior. (The tools include those specific to the product produced and used by various manufacturing technologies, such as shaping, transforming, separating, coating, or fitting; Typical technologies for primary shaping are molding or casting, for transforming are bending or stamping, for separating are milling or lathing, for coating are painting or surface coating, and for fitting are welding or riveting);

- Process plan information to manage the relationships among parts and the tools used to manufacture them and to manage the relationships between intermediate stages of parts or tools, referred to as in-process parts;
- Product definition data and configuration control data pertaining to the design phase of a product's development;
- Changes of a design, including tracking of the versions of a product and data related to the documentation of the change process;
- Management of alternate representations of parts and tools during the design phase;
- Identification of standard parts based on international, national, or industrial standards and library parts, based on company or project conventions.
- Release and approval data for various kinds of product data;
- Data that identify the supplier of a product and any related contract information;
- Any of eight types of representation of the shape of a part or tool:
  - ⇒ 2D-wireframe representation;
  - ⇒ 3D-wireframe representation;
  - ⇒ geometrically bounded surface representation;
  - ⇒ topologically bounded surface representation;
  - ⇒ faceted-boundary representation;
  - ⇒ boundary representation;
  - ⇒ compound shape representation;
  - ⇒ constructive solid geometry representation.
- Shape representation of parts or tools that is a mixture of the types of shape representation given above (hybrid model);
- Data that pertains to the presentation of the shape of the product;
- Representation of portions of the shape of a part or a tool by form features;
- Product documentation represented by explicit and associative draughting;
- References to product documentation represented in a form or format other than that specified by ISO 10303 (Other forms or formats may be physical clay models, digital data in other standard formats such as NC-data according to ISO 6983, or text data according to ISO/IEC 8879 Standard Generalized Mark-up Language (SGML));
- The simulation data for the description of kinematic structures and configurations of discrete tasks;
- Kinematics simulation of a windshield wiper.
- Properties of parts or tools;
- Surface conditions;
- Tolerance data.

The following are **<u>outside</u>** the scope of this part of ISO 10303:

- Product definition data pertaining to any life cycle phase of a product not related to design;
- Business or financial data for the management of a design project;
- A general parametric representation of the shape of the part or tool;

- Data describing the pneumatic, hydraulic, electric, or electronic functions of a product;
- Continuous kinematics simulations over time;
- Data describing the input or output of finite element analysis.

AP214 has 18 Conformance Classes (See Appendix for more detail)

The conformance classes are defined for the following application areas:
-- conformance classes 1 to 5 for CAD/CAM;
-- conformance classes 6 to 10 for product structure and configuration management;
-- conformance classes 11 to 13 for process planning;
-- conformance classes 14 and 15 for feature based design;
-- conformance classes 16 and 17 for simulation and quality control;
-- conformance classes 18 and 19 for configuration control of process planning with 3D digital mockup data exchange and sharing;
-- conformance class 20 for complete data storage and retrieval.

The conformance classes are characterized as follows:

cc 1: Component design with 3D shape representation
cc 2: Assembly design with 3D shape representation
cc 3: Component drawings with wireframe or surface shape representation
cc 4: Assembly drawings with wireframe, surface or solid shape representation
cc 5: Styling data
cc 6: Product data management (PDM) without shape representation
cc 7: Product data management (PDM) with 3D shape representation
cc 8: Configuration controlled design without shape representation
cc 9: Configuration controlled design with 3D shape representation
cc 10: Configuration controlled design with shape representation and draughting data .
cc 11: Process planning of components
cc 12: Process planning of components with form feature and tolerance data
cc 13: Effectivity controlled process planning of assemblies
cc 14: Feature based design
cc 15: Feature based design with flexible feature placement
cc 16: Kinematic simulations for components and assemblies with 3d shape representation
cc 17: Measured data
cc 18: Configuration controlled process planning of components and assemblies with 3D shape representation and kinematic data
cc 19: Configuration controlled process planning of components and assemblies with 3D shape representation including form features and kinematic data
cc 20: Data storage and retrieval systems

2.6.6 AP227: Plant Spatial Configuration

This part of ISO 10303 specifies the use of the integrated resources necessary for the exchange of spatial configuration information of process plants. The spatial configuration information includes the shape, spatial arrangement, and other characteristics of the plant piping systems.

Components of the plant piping system include pipes, fittings, pipe supports, valves, in-line equipment, and instruments. Shape and spatial arrangement information for equipment and non-piping plant systems are also included. The primary life cycle phase intended for this AP is design. Other life cycle phases that can make beneficial use of this data include fabrication, installation, and maintenance of plant piping systems.

The following are **within** the scope of this part of ISO 10303:

- The shape and spatial arrangement of plant systems within the process plant;
- Explicit representation of the 3D shape of plant piping systems;
- Explicit representation of the 3D external shape of plant piping system components and equipment (The representation may include envelope, outline and detailed representations as well as a parametric representation of the external shape);
- The logical configuration of the plant piping system and the relationship of the logical configuration to the planned physical piping system design;
- Basic engineering data as needed for spatial layout and configuration of the plant piping system;
- References to functional requirements of the plant piping system, such as stream data and operational characteristics;
- References to or designation of functional characteristics of piping components and connected equipment;
- The identification, shape, location, and orientation of reserved areas, volumes, and space-occupying elements of a plant that are not part of heating, ventilation, and air conditioning (HVAC), piping, structural, electrical, or instrumentation and controls systems;
- References to specifications, standards, guidelines, or regulations, for the plant piping systems, components, or connected equipment that may specify physical characteristics of the system or component;
- Status of spatial arrangement of piping components, piping components, and connected equipment;
- Connections and connection requirements for piping components and equipment;
- Definition of piping component design data sufficient for the acquisition of the components;
- Change request, approval, notification, verification, tracking of differences between versions of piping system design information, tracking of changes to plant items and attributes of plant items;
- Specification of the chemical composition of the streams carried by the plant piping systems in sufficient detail to evaluate the suitability of piping components for the desired process.

The following are **outside** the scope of this part of ISO 10303:

- 2D schematic representations;
- The contents of specifications, standards, guidelines, or regulations;
- Information required for the assembly and erection of non-piping plant systems or the manufacture of components of these systems;
- Specification of the chemical composition of the streams carried by the plant piping system in sufficient detail for process flow design;

- Process design;
- Plant operating procedures;
- Commercial aspects of procurement procedures;
- Internal design of equipment.

AP227 has 4 Conformance Classes: (See Appendix for more detail)

The conformance classes are characterized as follows:

cc 1: Piping system functional information;
cc 2: Equipment and component spatial information;
cc 3: Plant layout and piping design information
cc 4: Piping fabrication and installation information

All four conformance classes include information concerning plant item characterization, piping component characterization, connectors, connections, and change information.

2.6.7 AP232: Technical Data Packaging Core Information and Exchange

"This part of ISO 10303 will provide the structure to package/relate groups of product information so that configuration controlled exchanges can be achieved among Product Data Management (PDM) systems. Each group of product information being packaged by this AP may be exchanged in this AP's STEP format, another AP STEP format, or any other format agreed to by the exchanging partners. This capability will satisfy the industrial need to communicate and share the total design definition of a product among originating organization, partners, vendors, and customers. The goal of this application protocol is to provide an information structure where product information can be electronically captured and managed from both a product item perspective and a document based perspective.

Current Product Data Management (PDM) systems being installed in industry still manage documents but from a product view point. Currently no STEP AP addresses a document configuration structure for product data. This AP will deal with filling this document configuration structure void. The consequence of not developing this AP will be that enterprises and industries that have large infrastructures that rely on document based management systems will be reluctant to implement STEP due to a large initial investment they would have to make to change systems and procedures. This AP allows these industries an expedient migration path into STEP and into configuration control of product data from a product item perspective.

There are two aspects to AP 232. The first is the packaging of product data groups. The second is to provide the exchanged requirements of individual product data groups focusing on associated list information such as parts list, data list, index list, indentured data list, and applications list.

The packaging aspect provides the requirements for collecting, organizing, and managing the exchange of a complex set of data files or database views representing the different product data groups that define a product. A product data group defines a particular view of product information and may be identified and managed as a document, or product data set or a unique view within a database. Drawings, Associated lists and Reference Documents are considered product data groups. The result of packaging product data groups is called a Technical Data

Package (TDP). As a result of this packaging, AP 232 defines the interoperation of other ISO 10303 Parts (e.g. ISO 10303-203 and ISO 10303-202) and the managed inclusion of a mixed set of standards for representation of the various TDP elements (product data groups)."

AP232 has 14 Conformance Classes:

The conformance classes are characterized as follows:

cc 1: Data definition exchange (DDE) for files;
cc 2: Data definition exchange (DDE) for TDP elements;
cc 3: Data definition exchange (DDE) for indentured methods;
cc 4: Parts list (PL);
cc 5: Data list (DL);
cc 6: Indentured data list (IDL);
cc 7: Index list (IL);
cc 8: Other list (OL);
cc 9: List with presentation (cc 9 shall be implemented with one or more of cc 1 - 8.);
cc 10: Reference document identification and drawing identification;
cc 11: Reference document identification and drawing identification with ISO 10303-201 and ISO 10303-202 drawing presentation identification;
cc 12: Product data set (PDS) without presentation format (includes 3D models with surfaces and solids);
cc 13: Product data set (PDS) with shading (includes conformance class 12 and shading information);
cc 14: Product data set (PDS) with presentation format (includes cc 13, tolerances, annotation, and presentation information for human readability.

cc 11 combines conformance class 10 with the drawing structure and administration capability found in ISO 10303-505.

cc 14 combines the capability of product shape geometry with presentation annotation and tolerances

The next section provides short descriptions of "suites" of STEP Application Protocols as they apply to general application domains. In contrast to the way in which AP214 - "Core Data for Automotive Mechanical Design Processes" addresses the Automotive domain in a single Application Protocol, the following "suites" use a series of Application Protocols to address the application domain. Here, we briefly identify the Manufacturing Suite, the Shipbuilding Suite, the Process Plant Suite, and the Electrical/Electronic Suite and indicate some of the pilot/prototype/prove-out activities in these application domains. Some additional references are cited for further information.

2.7 Manufacturing Suite

AP213 - Numerical Control Process Plans for Machined Parts - DIS (See earlier description of scope and conformance classes)

AP224 - Mechanical Product Definition for Process Planning Using Machining Features - IS (See earlier description of scope and conformance classes)

AP219 - Manage dimensional inspection of solid parts or assemblies
"This application protocol will specify information requirements to manage dimensional inspection of solid parts or assemblies, which includes administering, planning, and executing dimensional inspection as well as analysing and archiving the results. Dimensional inspection can occur at any stage of the life cycle of a product where checking for conformance with a design specification is required.

The following are excluded from the scope of AP219:

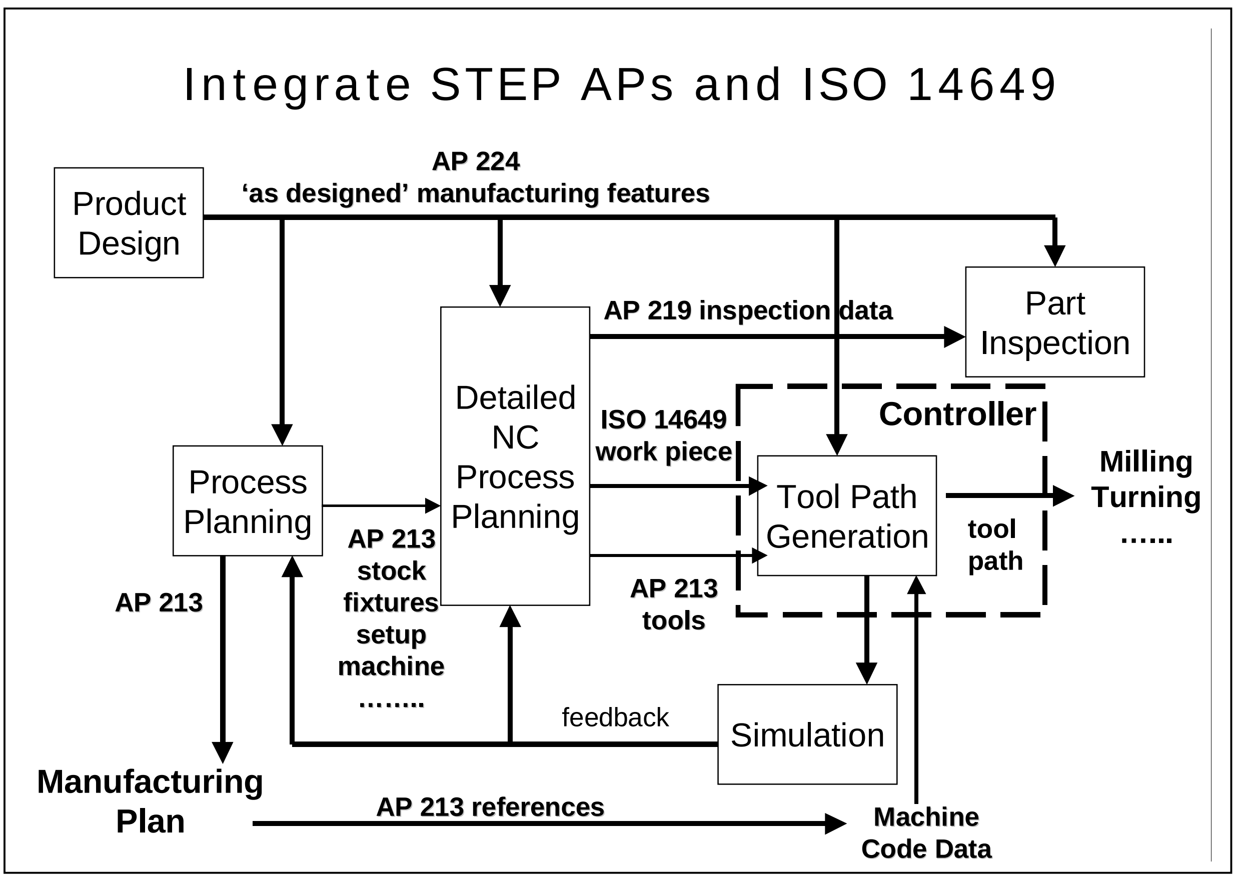
- Developing or modifying manufacturing process information*
- Generating geometry (creating the CAD model)*
- Generating tolerance requirements*
- Inspection of material properties

* These activities are considered out of scope, but the information resulting from these activities may be used by the Application Protocol."

ISO 14649-11 - Data Model for Computerized Numerical Controllers (CNC)
The purpose of ISO 14649 - 11 is to:

- Re-establish an accepted standard for the transmission of NC data to the shop floor!
- Provide motion control data based on splines for sophisticated, high-speed NC cutting operations
- Avoid intermediate data formats (CLDATA)
- Provide all necessary data for easy modification of NC data at the machine controller
- Replaces the old "M and G" codes with "working steps"

The diagram below shows an integration/implementation scenario for the Manufacturing Suite.



2.8 Shipbuilding Suite

(AP212, AP215, AP216, AP217, AP218, AP226, AP234, ISO 13584 (PLIB))
See: **http://www.nsnet.com/NIDDESC/t23.html**

Note: Extensive International Cooperation and Participation --- NIDDESC, EMSA, JECALS, KS-STEP leadership

EMSA = European Marine STEP Association
JECALS = Japan EC/CALS
KS-STEP = Korean Ship - STEP
NIDDESC = Navy/Industry Digital Data Exchange Standards Committee

AP 215: Ship Arrangements
Specifies the information requirements for the exchange of product data representing a ship's internal subdivision information between different organizations with a need for that data. Such organizations include ship owners, design agents, and fabricators. This AP has been developed to support the shipbuilding activities and computer applications associated with the Functional Design, Detail Design, and Production Engineering life cycle phases for commercial or military ships. The types of design activities and computer applications supported include naval architectural analyses (e.g., Damaged Stability, Compartmentation and Access, and Floating positions), structural analysis, interference analysis, and weight analysis.

AP 216: Ship Moulded Forms
Specifies the information requirements for the exchange of ship moulded forms and related hydrostatic properties. The AP supports hull moulded forms and moulded forms for structures internal to the ship, and supports surface and underwater ships for commercial and military use.

AP 217: Ship Piping (Significant overlap with AP227 - Possible "Merge"/Replacement)
Specifies the information requirements for the exchange of ship piping functional design, detail design, production engineering, fabrication, assembly and testing.

AP 218: Ship Structures
Specifies the information requirements for exchange of ship structural systems data for ship predesign, design, production, and inspection/survey. Product definition data pertaining to the ship's structure includes: hull structure, superstructure and all other internal structures of commercial and naval ships.

AP 226: Ship Mechanical Systems
Specifies the information requirements for exchange of ship mechanical systems information. This includes the exchange of information related to deck, propulsion and other mechanical systems in a ship product model. Connectivity between components and systems geometry, materials, topology and tolerances, noise, vibration and shock characteristics, component/system life cycle and operational history are part of the product model. Contains quality assurance information on availability, reliability, and maintainability.

AP234: Ship Operational Logs, Records, and Messages - New Work Item (NWI) (1999)"

STEP Shipbuilding Prototypes and Demonstrations:

- Computational Fluid Dynamics in the Ship Design Process (CALYPSO)
  http://www.oss.dk/resdev/internationalprojects/calypso.htm

- Electronic Data Interchange for the European Maritime Industry (EDIMAR) http://www.biba.uni-bremen.de/projects/edimar/summary.html
- MariTech STandard for Product model exchange (MariSTEP) http://www.intergraph.com/federal2/projects/step/
- Models for Operational Reliability, Integrity, and Availability Analysis of Ship Machinery Systems (MOSys) http://www.biba.uni-bremen.de/projects/mosys/
- Parts Library and STEP for Shipbuilding Product Data (PLSSPD) http://www.tda.ecrc.ctc.com/plsspd/home.htm

2.9 Process Plant Suite

(Primary AP's = AP221, AP227, AP231)
NIST Leadership with extensive International cooperation and participation

AP221 - Functional Data and Their Schematic Representation for Process Plant - This AP addresses functional data and some physical data for plant items and systems. Within the scope are schematics (e.g., P&ID and data sheets); standard data for piping, values, vessels, instrumentation and some equipment; and data repository concepts
AP227 - Plant Spatial Configuration - DIS (See earlier description of scope and conformance classes) - The emphasis of this AP is on piping design. It includes physical and functional characteristics and references to specifications and stream design cases.
AP231 - Process Design and Process Specifications of Major Equipment - The scope of this AP includes process simulation, unit operations, and the conceptual design of major process equipment.
& Related AP's:
AP212 - Electrotechnical Design and Installation - DIS (See earlier description of scope and conformance classes)
AP225 - Building Elements Using Explicit Shape Representation - IS (See earlier description of scope and conformance classes)
AP228 - Building Services: Heating, Ventilation, and Air Conditioning - Withdrawn
AP230 - Building Structural Frame: Steelwork - About to be withdrawn due to lack of resources

Projects/Prototype Implementations (with AP's addressed):

- EPISTLE - European Process Industries STEP Technical Liaison Executive (AP221)
- POSC/Caesar - development of "STEP-like" standards in the oil and petrochemical industries
- SPI-NL - Standard for Plant Information in the NetherLands
- pdXi - process data eXchange institute (AP231)
- PlantSTEP - (NIST, Bentley, Dassault, Intergraph) (AP227)
- PIEBASE - Process Industry Executive for achieving Business Advantage using Standards for data Exchange (AP221, AP227, AP231)
- ProcessBase - (ESPRIT)- (AP221)

2.10 Electrical/Electronics Suite

AP210 - Electronic Assembly, Interconnect and Packaging Design - DIS (See earlier description of scope and conformance classes)

AP212 - Electrotechnical Design and Installation - DIS (See earlier description of scope and conformance classes)

AP220 - Process Planning, Manufacture, and Assembly of Layered Electronic Products - Currently inactive (i.e., withdrawn), but soon to be re-initiated following the registration of AP210 as an IS. - The scope of this AP includes the information required to describe the functional capabilities of the equipment in a manufacturing facility and the process plan for producing the product in a specific facility or facilities.

The electrical/electronic subset of STEP standards is administered jointly under the International Organisation for Standardisation (ISO) and the International Electrotechnical Commission (IEC). Currently that subset consists of AP210 (Electronic Assembly, Interconnect, and Packaging Design), AP212 (Electromechanical Design and Installation), and AP220 (Process Planning, Manufacture, and Assembly of Layered Electronic Products). Each of these AP's has been piloted in programs such as Pre-Competative Advanced Manufacturing Program (PreAMP) (AP210, AP220), Team Integrated-Electronic Response (TIGER) (AP210, AP220), and a research program on raw materials and advanced materials (Brite EuRam) (Siemans) (AP212), and RAMP (AP210, AP220), while under development, to exercise, enhance, and validate their capabilities and robustness. Industry-wide consortia such as PDES, Inc. (based in the United States) and ProSTEP (based in Europe) have memberships committed to the development and implementation of STEP. Companies such as Rockwell Collins, Boeing, Delphi/Delco Electronics, Siemens, Ford, Lockheed Martin, Digital, IBM, Northrop Grumman, and Hughes have been leaders in the Electrical/Electronic development of STEP.

The PreAMP and TIGER programs were managed by SCRA's Advanced Technology Institute (ATI). The Pre-competitive Advanced Manufacturing Processes (PreAMP) program was a National Institute of Standards and Technology (NIST) Advanced Technology Program (ATP) funded project that addressed standards-based concurrent design processes and tools for printed circuit assemblies (PCA's). The TIGER program dealt with deploying cost effective, collaborative electronic commerce for PWB's and PWA's. TIGER was funded by the Defense Advanced Research Program Agency (DARPA).

The STEP Electrical/Electronics Suite provides the description of all aspects of an electronic assembly throughout its lifecycle (AP210), and the description of the functional capabilities of the equipment in a manufacturing facility and the process plan for producing the product in a specific facility or facilities (AP220). In addition to the Electrical/Electronics Suite, AP212 fits into numerous other application domains such as process plant, building construction, and transportation systems.

Projected AP210 Implementations:

- Mentor Graphics has a commercially available AP210 Translator that was developed by International TechneGroup, Inc. (ITI) and supported and marketed by ITI
- Cadence
- Zuken-Redac

3.0 Other Product Data Exchange Specifications & Standards

Other "de facto", national, international product data exchange (PDE) standards exist and have been widely implemented. Many were originally developed to address 2D draughting (e.g., IGES, SET, VDA, DXF, DWG). Others such as EDIF, IPC, and Gerber were developed to address "point" solutions for different aspects of the Electrical/Electronic design process (e.g., schematic, netlist, photo plot, …).

There are certainly instances where these PDE solutions are appropriate. There are other instances where perhaps direct translation is most appropriate. Most of the major vendors provide multiple PDE solutions/tools, and some provide PDE translation services. Several web sites are cited for further discussion on the use of other PDE formats.

This section identifies most of the "popular" PDE specifications and standards and provides a table of Vendor STEP and other PDE capabilities. There is also some discussion about direct translators, translation service centers, STEP tools, and solids modeling kernels for some of the major CAD/CAM systems.

Other PDE Standards:

IGES - Initial Graphics Exchange Specification --- ANSI Standard (Latest Version 5.3 - 1997) - Initially (ANSI Y14.26M-1981) addressed 2D and 3D drawing data, later added Solid Model data (CSG & B-Rep), Piping, Drafting and Electrical Subsets/Application Protocols also now exist. (Virtually every CAD/CAM vendor has an IGES translator for their system.)

SLC - Rapid Prototyping - Stereolithography - 3D Contour based data format

STL - (3D Systems, Inc.'s Stereolithography Interface Specification (SIS) - Public Domain) - 3D vectorized/triangulated data - Widely used "de facto" industry standard.

DXF - (AutoDesk/AutoCAD Proprietary - Public Domain) - Widely used "de facto" industry standard.

DWG - (AutoDesk/AutoCAD Proprietary - Public Domain) - Widely used "de facto" industry standard.

ACIS (.sat) - (Spatial Technologies Proprietary - Public Domain) - A Solid Modeling System developed and marketed by Spatial Technology, Inc. - ACIS is the solid modeling kernel for numerous commercial CAD systems (e.g., AutoCAD, Mechanical Desktop, CADKEY, IronCAD, …) "It supports 3D surfaces and solids and is based upon NURBS and B-rep solid modelling."

ParaSolid (.xmt, .x_t) - (UGSolutions - Proprietary) - A Solid Modeling System developed and marketed by Unigraphic Solutions - Parasolid is the solid modeling kernel for numerous commercial CAD systems (e.g., Unigraphics, SolidEdge, SolidWorks, …) "It supports 3D surfaces and solids and is based upon NURBS and B-rep solid modelling technology."

VDA - Verband der Deutsche Automobilindustrie - German DIN Standard

VDA-IS (1.0) - "IGES Specification - A subset (primarily for the exchange of drawings) of IGES used in the German Automotive Industry (DIN 66 301) - "standard to exchange two-dimensional basic CAD geometry and dimensions."

VDA-FS (2.0) - VDA/Flachen Schnittstelle- "neutral format for exchanging surface data between different CAD systems. Developed in Germany by VDA." (Includes/addresses trimmed surfaces)

SET - Standard d'Exchange et de Transfert - French AFNOR Standard (Z68-300) - Initially (1985) - Very much like IGES in content with a different, more efficient file structure. Has added coverage of Finite Element Modeling (FEM), Numerical Control (NC) and Solid Modeling (CSG, Advanced B-Rep, and Facetted (polyhedral) B-Rep) - Developed by Aerospatiale. Maintained by GOSET.

JEDMICS - U.S DoD repository for archiving Technical Data Packages - They are primarily stored in CCITT Group 4 Raster format, but JEDMICS is capable of storing virtually any format.

There is a nice discussion on IGES/SET/VDA and STEP @ http://www.theorem.co.uk/docs/standard.htm (from which several of the above descriptions were taken) and http://www.ukcic.org/step/pages/stpgolb1.htm

A report from the GM STEP Testing Center comparing STEP AP203 and IGES for Surface and Solid models can be found in the PDES, Inc. Public Archives @ http://pdesin.aticorp.org/whatsnew/archives/step_overview.html

Electrical/Electronics Product Data Exchange Standards:

EDIF- ANSI/EIA Standard (Versions 2 0 0, 3 0 0 & 4 0 0 have numerous ECAD Implementations (primarily EDIF 2 0 0)) - including schematic & netlist data

IPC D35x - ANSI Standard for electrical/electronic connectivity

Raster CCITT Group 4 --- An International Standard for raster data

Gerber - Widely used Industry "de facto" photo plot standard

VHDL - ANSI/IEEE - Functional behavioral modeling language standard for electrical/electronic circuits

There are national and international standards; there are *de facto* and industry standards. They have varying levels of data coverage and acceptance. Typically, in the electrical/electronics domain, the Electronic Design Interchange Format (EDIF) has been used for the schematic and netlist; the format of the Institute for interconnecting and Packaging electronic Circuits (IPC) has been used for board layout and connectivity; the Initial Graphics Exchange Specification (IGES) has been used for the mechanical structure of the board, and the Gerber photoplot format has been used for photo layout. EDIF, IPC and IGES are American National Standards Institute (ANSI) standards; Gerber is a *de facto* industry "standard". Each of these provide "point" solutions for electrical/electronic product data exchange (i.e., schematic to schematic, layout to layout, mechanical to mechanical,…). They do not provide an integrated approach to the entire lifecycle of the products. For years, there have been attempts to harmonize the electrical/electronic product data exchange standards with only a modicum of success.

AP210 addresses the design of electronic assemblies, their interconnection and packaging. Within its scope are the “as-required”, “as-designed” and “as-used” product information for the “in process” design and the “release” design. AP210 product data can be shared across several levels of the supply base and between design, analysis and manufacturing. AP210 provides a single data model which allows 3D component geometry, 2D bare board artwork, abstract behavioral models, and electrical network connections to be described and interrelated (i.e., all the information needed to manufacture a PCA).

CADCAM/CAE Vendor STEP Capabilities

The following table provides a summary of commercially available STEP translators for most of the major CAD/CAM/CAE vendors and comments on some of their near term future implementation plans. Each of these vendors has some level of STEP AP203 and "AP214" translator. This table was compiled from survey inputs from the vendors and CAx-Implementor Forum presentations. The table represents a “snap shot” of the status of commercially available STEP Translators at this point in time. **All of these vendors have other translators as well (e.g., Direct, IGES, DXF, etc.).**

Vendor	AP203	AP214	Comments
Alias/Wavefront: Studio/Design Studio/Surface Studio/Auto Studio v9.5	cc 1*, 2, 4, 6	cc 1, 2	
Autodesk: Mechanical Desktop (R4.1) AutoCAD 2000 Inventor R2	cc 1*, 2, 4, 6 +Colors, Layers, 3D Annotation modules & Groups cc 1*, 2, 4, 6 +Colors, Layers, 3D Annotation modules & Groups cc 1*, 2, 4, 6	cc 1, 2 including Colors, Layers, 3D Annotation, & Groups cc 1, 2 including Colors, Layers, 3D Annotation, & Groups cc 1, 2	cc 6a Certified, Geometric Validation module planned for 2000. Feature module planned for the future(Both AP203&214) Geometric Validation module planned for 2000. (Both AP203 & 214) Colors & Geometric Validation modules planned for 2000
Bentley: Microstation J Microstation Modeler/J Microstation(Parasolid Edition)	cc 1*, 2, 3, 4, 5*, 6 + Colors & Layers – Import only cc 1*, 2, 3, 4, 5*, 6 + Colors & Layers – Import only cc 1*, 2, 3, 4, 6 +Colors	cc 1 including Colors & Layers – Import, Export cc 1, 2 including Colors & Layers – Import, Export	Validation Prop's - Prototype AP227 - Prototype AP225 - Planned AP203 via ACIS (cc6 = .sat) Validation Prop's - Prototype
CADKEY Corp: CADKEY 98	cc 1*, 2*, 4*, 6	cc 2*	
CNC Software: MasterCAM v7.2+/v8	(Import only) cc 1*, 2*, 4*, 6*	(Import only) cc 1*	Export planned for Future
CoCreate: SolidDesigner 7.0	cc 1*, 2, 4, 6	cc 1, 2	
Dassault Systemes & IBM: CATIA v4.2.2/v4.2.3 CATIA v5	cc 1*, 2*, 3*, 4, 5, 6 + Prototype Color, Layers&Annotation modules cc 1*, 2*, 3*, 4, 5, 6	cc 1, 2* including Prototype Colors & Layers cc 1, 2 in 2001	cc 6a Certified Have AP227 (cc2) cc 6a Certified, Have

Vendor	AP203	AP214	Comments
SolidWorks	Have Proto Annot. Color, Layers, Geo Validation in 2000 cc 1*, 2, 4*, 5*, 6 Colors in 2000	cc 2*	AP227(cc2), Have AP 221 Prototype, Planning AP209, 210 & 212 development. Considering APs202,213,224&232 cc 6a Certified
debis CATIA 3.1.1	cc 1*, 4, 5, 6	cc 1,2,4,6	Planning for ver's 4.0.1 & 5.0.0 to include cc 15 (features) & cc 6 (PDM)-AP214
ITI: ACIS/STEP I-DEAS Mentorgraphics	 cc 1*, 2, 4, 6 cc 1*, 2, 4, 6	 cc 1, 2* cc 1, 2	 See SDRC AP210 (cc 4-9,14,17,23)
Knowledge Technology: KBO (v1.0 - ICAD 7.0)	cc 1*, 2, 6		
LSC Group LOCAM	cc 1*, 2*, 3*, 6		AP224 (IS) Postprocessor (In)
Matra Datavision: Euclid Designer	cc 1*, 2, 3, 4, 6	cc 1, 2	
McNeal Schwendler: Patran (v 8 & 9)	cc 1*, 2, 3#, 4#, 5#, 6 (#=Import only)	cc 1, 2	Prep for cc 6a Certification AP209 (cc's 1-8, 10, Proto cc9) Valid Prop's modules for AP's 203 & 214 in 2000 Future- AP's 216. 218, 227, 210
MICROCADAM, Inc.: Helix 2000 v4r1	cc 1*, 2, 4, 6	cc 1, 2*	
PTC: Pro/ENGINEER 2000i[2] CADDS5 (Rel 10) CADDS5 (Rel 11)	 cc 1*, 2, 4, 6 + Colors, Layers, Validation Prop's modules & Groups cc 1*, 4, 6 cc 1*, 2, 4, 6	 cc 1, 2, 8 +external file ref. cc 1	 AP202 (In-cc 1-5, 8-10, Out 1, 5, 8,9) Prep for cc 6a Certification Ship Bldg & E/E planned Dev'd by ITI Dev'd by PTC
SDRC: I-DEAS Artisan v7.0 (MS)	cc 1*, 2, 4, 6 +Color	cc 1, 2	ITI developed
Spatial, Inc. 3dshare	cc 1*, 2*, 3*, 4*, 6* (Import only)	cc 1*, 2*, 3*, 4* (Import only)	Web based Translation Service STEP/ACIS(.sat) & STEP/IGES
STEP Tools, Inc.: ST- ACIS v6.0 ST- Parasolid v11.0 ST-Viewer v3.1	 cc 1*, 2, 3, 4, 6 Color, Layer, Valid Prop's - Prototype cc 1*, 4, 6(2,3 in'00) Color, Layer, Valid Prop's - Prototype cc 1,2,3,4,5,6+color Layers & Valid Prop's - Planned	 cc 1, 2, 9* 12, 14 - Planned cc 1, 2, 9* Possibly 12, 14 cc 1, 2, 9 Possibly 12, 14	Also AP203 with STL, GIF, JPEG, VRML & Part 21 -> XML AP224 - Planned AP224 - Planned ISO 14649 - Planned in 2001

Vendor	AP203	AP214	Comments
			Possibly AP's 224 & 227
Surfware, Inc.: SurfCAM			No STEP Translator, Has ACIS translator, Could use an ACIS/STEP translator to import STEP AP203/AP214 files
Team SCRA: STEPTrans (Pro/E) STEPPlan (ICAD)	 cc 1*, 2*, 3*, 6 cc 1*, 2*, 3*, 6		 AP224 (IS) Preprocessor (Out) AP224 (IS) Postprocessor (In)
Theorem Solutions: ACIS/STEP (v 1.6 -> 5.1) Parasolid/STEP(v 7.1->11.0) CADDS4X (all versions) CADDS5 (all versions) CATIA (v3&4) Unigraphics (v 13, 14, 15) I-DEAS (versions M56, M57) SolidWorks (v 98 & 99) SolidEdge (v 6 & 7) Autodesk Mech Dsktp(R4) ICEM	+ Colors, Tags & Validation Prop's cc 1*, 2, 3, 4, 5, 6 cc 1*, 2, 3, 4, 5, 6 cc 1*, 2, 3, 4, 5, 6 cc 1*, 2, 3, 4, 5, 6 cc 1*, 2, 3, 4, 5, 6 cc 1*, 2, 3, 4, 5, 6 cc 1*, 2, 3, 4, 5, 6 cc 1*, 2*, 3*, 4, 5, 6 cc 1*, 2*, 3*, 4, 5, 6 cc 1*, 2*, 3*, 4, 5, 6 cc 1*, 2, 3, 4, 6*	 cc 1, 2 cc 1, 2 cc 1, 2 cc 1, 2 cc 1, 2 cc 1, 2 cc 1, 2*	Planning AP214 Draughting cc's (<u>not</u> AP202) .sat or .sab .xmt or .x_t cc 6a Certification 2 Levels Fcnality Master Series via Parasolid via Parasolid
UGSolutions: Unigraphics v16/v17 SolidEdge v7 Parasolid v11 Bravo v6.0 "Intergraph" EMS	 cc 1*, 2, 4, 5*, 6 + Colors, Layers & Validation Prop modules cc 4 cc 1*, 2, 4, 6	 cc 1, 2 including Colors, Layers & Validation Prop's cc 1	 cc 6a Certified, Considering adding Annotation, Features, Geometric & Dimensional Tolerancing modules PS/STEP PS/STEP No further development, Owned/Maintained by UGSolutions

Commercially available "STEP" translators are almost exclusively AP203 and the essentially "equivalent" AP214 cc1 & cc2 translators. In other words, geometry (wireframe, surfaces, and advanced B-Rep solids) and a subset of configuration management data are what have been implemented. There are a few other commercially available STEP translators (AP202 - Pro/E, AP207 - CATIA, AP209 - MSC, AP210 - Mentorgraphics BoardStation (by ITI), and AP224 - Team SCRA/RAMP). The RAMP Program has its own process planning system (STEPPlan) which reads in AP224 and AP203 files, and several CAE vendors have indicated their intention to implement AP210 ("Soon To Be IS"). Others are still in the "planning" or negotiation stage with the vendors. The vendors need external funding or a business case to implement STEP AP's.

4.0 Direct Translators

It should be noted that a number of vendors and 3rd Party software development companies have developed direct translators for those CAD systems used frequently to exchange data. Below are some examples with references to related web sites.

- **Alias/Wavefront -** DesignStudio direct translation with I-DEAS, CATIA, and Unigraphics - http://www.aliaswavefront.com/design/products/consumer_products/designstudio/pdf_brochure/index.pdf
- **Compunix -** Numerous combinations involving CATIA, UG, and Pro/E - http://www.compunix-usa.com/products/products.htm
- **Dassault/IBM** - CATIA/ALIAS, CATIA/CADAM - http://www.catia.ibm.com/prodinfo/fniface.html#dxf
- **Matra Datavision -** Euclid Designer with CATIA, CADDS and others **-** http://www.epro.com.hk/products/matra/edesigner.htm
- **PTC -** direct geometry translators for CATIA®, PDGS, CADAM®,- http://www.ptc.com/products/proe/foundation/interfaces.htm
- **Theorem Solutions -** Combinations of CADDS, CATIA, SolidEdge, SolidWorks, Unigraphics, Mechanical Desktop, Pro/Engineer, etc. http://www.theorem.co.uk/docs/prodov.htm
  (To review: Select the CAD system listed in CADverter)
- **UGSolutions -** CATIA/UG. PDGS/UG, CADD4X/5->UG http://support.ugsolutions.com/services/data_exchange.html

Translation Services:

To meet the needs for product data exchange (usually for small and medium sized enterprises (SME's)), translation services have been established by some of the major players in the STEP community. More information on these translation services can be obtained by visiting the indicated web sites.

- **IBM CAD Data Exchange Service** **(**http://service.software.ibm.com/indsolutns.us/go?/mktdocs/support/igesserv.html
- **ITI Data Exchange (DEX) Center** **(**http://www.iti-oh.com/pdi/dexcenter/index.htm**)**
- **Spatial/IDA -** ACIS and Product Data Consulting **(**http://www.spatial.com/Support/consulting/consulting.htm**)**
- **STEP Tools, Inc. Translation Service** **(**http://www.steptools.com/strepo/translate.cgi**)**
- **Theorem Solutions -** Data Exchange Translation Services using both direct and STEP -based (AP203 or AP214) translators **(**http://www.theorem.co.uk/docs/bureau.htm**)**
- **UGSolutions -** Data Exchange Translation Services using both direct and standards-based (STEP AP203/214, flavored IGES, and DXF) translators **(**http://support.ugsolutions.com/services/data_exchange.html**)**

- **PDES, Inc. Prove-Out System (for Members only) -** "Tests"/Proves-out commercially available STEP (AP203 and AP214) translators for models in numerous CAD Systems. (Currently, there are 7 CAD Systems in the PDES, Inc. Prove-Out Lab.)

Solid Modelers: (See Vendor Web Sites for more detail on Products.)

- **Spatial Technology, Inc. -** ACIS - used as the solids modeling kernel in numerous CAD/CAM systems including AutoCAD, Mechanical Desktop, Design Studio, and others.
- **UGSolutions -** Parasolid - used as the solids modeling kernel in numerous CAD/CAM systems including Unigraphics, Solid Edge, SolidWorks, and others.
- **Co-Create -** SolidDesigner uses own proprietary solids modeling kernel.
- **Dassault -** CATIA uses own proprietary solids modeling kernel.
- **PTC -** Pro/ENGINEER uses own proprietary solids modeling kernel.
- **SDRC -** I-DEAS uses own proprietary solids modeling kernel.

Comment: In theory, if a user is using a CAD System with an ACIS or a Parasolid kernel, that user can generate or read .sat (ACIS) or .xmt or x_t (Parasolid) files. The user can then use an ACIS/STEP or a Parasolid/STEP translator, as appropriate, to generate or read a STEP AP203 (or AP214) file. This, theoretically, addresses STEP AP203/AP214 Advanced B-Rep translation for ACIS and Parasolid based systems.

STEP Tool Vendors:

In the development of both the STEP Standard and STEP translators, some companies have developed tools to facilitate the development. Most notably in the STEP community are the following:

- **EPM -** EXPRESS Data Manager Suite of tools for application development and integration (Contains EDMmodelConverter which "uses EXPRESS-X to convert data from one EXPRESS schema to another") **(**http://www.epmtech.jotne.com/products/index.html**)**
- **IDA -** (ACIS Translator Husks for IGES, VDA-FS and STEP and for direct translation between Pro/E and between CATIA) **(**http://www.spatial.com/Products/Husks/husks.htm**)**
- **ITI - (PDE/Lib, IGES/Works, CAD/IQ, CADfix) (**http://www.iti-oh.com/pdi**)**
- **"NIST"**
  - ⇒ **EXPRESSO** (EXPRESS Language Environment) ("Freeware") **(**http://www.mel.nist.gov/div826/staff/denno/nist-expresso.html **)**
  - ⇒ **FEDEX** (EXPRESS Compiler) ("Freeware") **(**http://pitch.nist.gov/cgi-bin/sauder/express-server/server.cgi)
- **PDTec -** ECCO Toolkit (EXPRESS Compiler) ("provides the building blocks … and a software development environment to … implement product data technology" - (http://www.pdtec.de/)

- **STEP Tools, Inc. -** ST-Developer (to build and maintain STEP Applications) - (http://www.steptools.com/products/)

Also to be noted in the category of "tools" to help users are the "trouble shooting" tools such as CAD/IQ from ITI, and the geometry "healers" built into translators from Theorem Solutions, CATIA, Unigraphics, Pro/ENGINEER, and others.

5.0 Some Pilot & Prototype Implementations & Prove-outs

At this point in time, robust commercial STEP translators include AP203 (cc's 1*, 2, 4, and 6) and AP214 (cc's 1 & 2). These translators have been proved-out through rather extensive testing in forums such as PDES, Inc's STEPnet, ProSTEP's rally, and now the joint PDES, Inc./ProSTEP CAx-Implementors Forum. The early problems with accuracy and interoperability have essentially been eliminated, and the translators are of good quality.

Commercial implementation of other STEP AP's, with only a few exceptions as noted above, is rather slow in coming. But, this is not to say that other STEP AP's are not being tested. In fact there are, and have been, numerous pilots, prototypes and prove-outs throughout the world that are showing that STEP AP's in a wide variety of application domains can and do meet the requirements specified in the scopes of these application protocols.

These activities and the successes that they are demonstrating show that there is significant support throughout the world, especially in the CAD/CAM user community, for STEP to succeed. Most of the countries participating in TC184/SC4 have established STEP Centers. There are many STEP related R & D projects funded by national governments throughout the world. The CAD/CAM/CAE vendors participate in these prototyping projects to the extent to which they are funded. There is still limited vendor commitment to producing commercial STEP translation products at this point in time.

To illustrate the extent of the STEP related piloting activities, some of these many activities will be cited below with references given to web sites for additional information.

The SCRA's Advanced Technology Institute (ATI) houses PDES, Inc. which is an industrial consortium chartered with accelerating the development and implementation of STEP. More than twenty major automotive, aerospace and CAD/CAM vendor and user companies actively participate in their numerous STEP projects. (visit http://pdesinc.aticorp.org/deploy.html)

PDES, Inc. Pilots:

- **STIR - STEP TDP Interoperability Readiness Pilot (AP232 & AP203 cc1)**
- **STEPwise - STEP web integrated supplier exchange (AP232/PDM)**
  - ⇒ An extension of the STIR Pilot
  - ⇒ Estimated Annual Pre-Production Savings per supplier - $64K
- **Eurofighter PDM Pilot (Unified PDM Schema)**
- **ISAP - International STEP Automotive Project**
  - ⇒ Joint with ProSTEP
  - ⇒ AP Interoperability (AP202, AP203, AP214)
  - ⇒ PDM
- **Electromechanical Pilot - AP210/AP203**
- **AEA - Aerospace Engine Alliance - AP203/PDM Schema**
- **Engineering Analysis - AP209**
- **TURBINE - AP203**
  - ⇒ Cross Section & Assembly Solid Models
- **AWS - Advanced Weapon System (AP203/AP202)**
- **CSTAR - (AP203 cc1) (**See Production Implementation @ McDonnell Douglas**)**

- **AeroSTEP - (AP203 cc5 & cc6) for Digital Pre-Assembly Solid (**See Production Implementation @ Boeing**)**

ATI - NIST

- **PreAMP- Precompetitive Advanced Manufacturing Program - AP210CD/AP220WD**

ATI - DARPA

- **TIGER - Team InteGrated - Electronic Response - An extension of PreAMP (AP210 DIS & AP220 WD)**
- **STAMP - Supply-chain Technologies for Affordable Missile Products - AP232/STEP PDM Schema**

DARPA

- **MARITECH STEP Program -** Accelerate STEP development and assess implementability in U.S. Marine Industry

AIAG

- **AutoSTEP - AP203 cc6**
  - ⇒ Publications (http://www.aiag.org/)
  - ⇒ STEP/IGES Comparison
  - ⇒ Direct Translator Comparison

ATI - USAF/WPAFB-WL

- **PAS-C - PDES Application protocol Suite for Composites - AP203/AP209/AP232/AP222**

ATI - TACOM

- **TACOM Pilot -** an extension of PAS-C with the Army - AP203/AP209/AP232/AP222

NIST

- **Plant STEP Consortium - AP225**
- **STEP AP213 Coverage Analysis Pilot**

Team SCRA/RAMP - DLA

- **STEP Feature-based Manufacturing Pilots**
- **Reports with Cost/Time Savings Metrics (**http://ramp.scra.org/ap224_reports.html**)**
  - ⇒ **RAMP/STEP Site Prove-outs Phases 1 & 2 - AP224/AP203**
  - ⇒ **RAMP/STEP Commercial Pilot @ Texas Instruments - AP224/AP203**
  - ⇒ **RAMP @ Focus:HOPE - AP224/AP203**
  - ⇒ **STEP for Small/Medium Manufacturers Pilot - AP203**

Siemens NG (Germany)

- **Brite EuRam Project - "Advanced Control Network - ACORN 1479" - AP212 (**http://www.atd.siemens.de/it-dl/step/eng/scc_01.htm**)**

European Projects (Many of these projects are funded by ESPRIT.)

- **European STEP Centres Network (ESCN) - (**http://www.uninova.pt/~escn/prodlinks.html**) (Many of the following projects are cited at the above web site.)**

- **EPISTLE : European Process Industries STEP Technical Liaison Executive - Data Model used by for AP221, AP227, AP231**
- **PIPPIN : Pilot Implementation of Process Plant Lifecycle Data Exchange Conforming To STEP - AP221**
- **PROCESSBASE : ... contributions to STEP AP221**
- **SEASPRITE : Software architectures for ship product data integration and exchange.** Electronic data exchange in the shipbuilding industry using STEP AP216 & AP218.
- **FunSTEP :** Furniture STEP Development of a data model based on STEP for the manufacturers - customers integration in furniture industries.
- **CIMSTEEL : Computer Integrated Manufacture for constructional STEELwork - AP230**
- **PISTEP - Process Industries STEP - AP221 & AP227**
- **PdXi - product data eXchange institute - has lead development of AP231**
- **Petrotechnical Open Software Corporation & Caesar Systems, Ltd (POSC/Caesar) -** project to develop "STEP-like" standards for the Oil and Petrochemical Industries

Japanese Projects (involving STEP) for the Process Industries

- **Power Plant STEP Working Group**
- **Plant CALS/STEP**

STEP Projects Index Page (This web site lists approximately 50 Research & Development Projects throughout the World using STEP Technology.)
http://www.marchland.com/piebase/project/index.htm

6.0 Some Production Implementations of STEP

Production STEP Implementations resulting from PDES, Inc. Pilot Projects: (http://pdesinc.aticorp.org/deploy.html) --- See Press Release Archives for more detail and projected cost/time savings.

- **CSTAR - C-17 STEP Transfer And Retrieval** - Went production in 1995 at McDonnell Douglas (now Boeing) using AP203 cc1
- **AEROSTEP/PowerSTEP** (Boeing) - Went production in 1995 with Rolls Royce (Catia/CADDS5 - AP203 cc6) - Went production in 1996 with General Electric and Pratt & Whitney (Catia/UG - AP203 cc6) - In 1997 entered into agreement with Rolls Royce, General Electric, and Pratt & Whitney to exchange data using STEP AP203 to support digital pre-assembly verification for the 777 and 767-400 aircrafts.
- **General Motors STEP Translation Center** - Went production in 1996 to test and validate surface and solid model data exchange. Extensive STEP/IGES comparison analysis. CATI/UG translation services with GM Powertrain, Delphi/Delco Electronics, and Delphi Automotive divisions.
- **Lockheed Martin - Tactical Aircraft Systems** - Went production in 1998 with the use of CATIA STEP AP203 translators for data exchange on the F-16, JSF, F-22, KTX-2, and F-2 aircraft Programs. In 1999, Lockheed Martin-Tactical Aircraft Systems (LM-TAS), undertook the Virtual Product Development Initiative for Finite Element Analysis (VPDI-FEA) using AP209 DIS.
- **NASA** - Statement of policy that STEP Translators are required to be available at all NASA Sites

Team SCRA's RAMP Program has had STEP-Driven Manufacturing in production at Anniston Army Depot since 1994. - The program developed Pro/ENGINEER STEP translator (STEPTrans) translates feature-based solid models into AP224 and AP203. The program developed process planning system (STEPPlan) uses the STEP files to develop process plans to drive the factory. STEPTrans, STEPPlan, and STEPValidator have evolved with the AP224 standard in this production environment over the years. These same STEP-based tools are used operationally in Team SCRA's On Demand Manufacturing (ODM) Vendor Network, comprised of over 50 companies. (See http://ramp.scra.org/ for greater detail)

The next section addresses the current STEP AP implementation status and provides some guidance on using what is available and on avoiding possible pitfalls. Once again, it is noted that until the latter part of 1999, only 3 STEP Application Protocols had achieved published IS status (i.e., AP201 & AP203 in 1994 and AP202 in 1996). Three additional STEP AP's were published as International Standards late in 1999. Six additional AP's are expected to reach IS status in 2000. STEP, the International Standard, is finally arriving on the scene. An examination of the scopes and associated conformance classes of these 12 STEP AP's indicates significant coverage of several important application domains. The standards represent considerable added capability. However, this capability can only be realized when the STEP AP's are implemented and available to the Engineering/Manufacturing community.

7.0 Some Guidance on Using STEP

In theory, the scopes of the Application Protocols and the defined Conformance Classes indicate the coverage of the various application domains. Numerous pilots, prototype implementations, and prove-out activities have taken place (especially over the past few years) lead by groups such as PDES, Inc. and ProSTEP and internationally funded projects in Shipbuilding and the Process Industries as well as the RAMP Program.

In reality, STEP in general use consists primarily of several conformance classes of AP203 (primarily cc6 and a subset of cc1, although most vendors have also implemented cc's 2 & 4) and cc1 and cc2 of AP214 which is essentially AP203 with a somewhat different set of CM data. These are the AP/cc implementations that most of the CAD/CAM Vendors have chosen to implement.

There are a limited number of production implementations of other STEP that involve part fabrication. One example is the RAMP/United Kingdom RAMP (UKRAMP) implementation of AP224. However, Vendors have been slow to implement other AP's until the AP's have reached IS status (so far 6 AP's have reached IS status, and 3 of those were not published until late in 1999) **and** until the User Community (i.e., their customers) requests these STEP translation capabilities in significant enough numbers.

So, at this point in time (from a production user point of view), when "we" talk about STEP, we really mean AP203 (cc's 1,2,4 & 6) and/or AP214 (cc's 1 & 2). However, we are now at a point in time when many of the other STEP AP development efforts are coming to completion. AP's 207, 224, and 225 have already achieved IS status. AP's 209, 210, 214, and 227 will achieve IS status in 2000. AP232 is a "high profile" AP that has lots of "users" "waiting in the wings" for it to achieve IS status. So, soon, when we talk about STEP, we (as "users") will have to be more specific --- we will have to "call out" the STEP AP and the conformance classes in which we are interested. STEP is more than AP203 and its "equivalents". This will put the vendor community in a quandary --- what STEP AP's will they implement? More specifically, what conformance classes of what AP's will they implement? These decisions will be "user"/customer driven! Implementing multiple STEP AP's (i.e., numerous conformance classes for numerous AP's) will potentially be a huge undertaking for the vendors and require a significant investment of time and resources to accomplish. Certainly a strong business case will have to be established for the vendors to undertake this effort. The "user" community will have to "step to the table" with money in their hands to make it happen. It almost certain that many of the STEP AP's (regardless of achieving IS status) will never be implemented as commercially available translators by the vendors. Some of these STEP AP's will get implemented "internally" within companies and shared with their supply chains in cases where the company feels that the costs are justified by the anticipated return on investment (ROI). Some companies will outsource this work to companies like ITI (as was the case for the AP210 implementation for Mentorgraphics' BoardStation).

It is highly unlikely that AP201 (IS in 1994) (STEP's "equivalent" of IGES's draughting specification) will ever be implemented by anyone. PTC has the only implementation of AP202 (IS in 1996), but other Vendors appear to be waiting for AP214 to reach IS and then will implement it's Draughting conformance classes (cc's 3, 4, and/or 10) which have been harmonized with AP202.

Probably the two STEP AP's with the greatest "visibility"/"momentum" at this point in time are the Core Automotive Design AP214 and the Technical Data Packaging ("PDM") AP232. Neither of these AP's have achieved IS status yet, but both have been and are currently being proven out with prototype/pilot implementations. In fact, many/most vendors have commercially available AP214 cc1 and cc2 translators (recall, however, that these are essentially equivalent to AP203 translators with a "different" set of CM data). There are numerous PDM vendors participating in the PDES, Inc./ProSTEP PDM - Implementors' Forum (PDM-IF) that have early/partial implementations of AP232 ("CD Version") using the consensus STEP PDM Schema. Some of these are being used in some PDES, Inc. and ProSTEP pilots.

In addition to ITI's commercially available AP210 Translator for Mentorgraphics' BoardStation layout design system, it is projected that Cadence and Zuken-Redac will follow with AP210 implementations of their own. It is not clear, at this point, what conformance classes have been or will be addressed by these translators.

A "commercially" available implementation of AP224 (through the various stages of ISO development - CD, DIS, FDIS and IS) developed by TEAM SCRA as a part of the RAMP Program has been available for several years and in production with the RAMP's process planning system at several sites. This is a Pro/ENGINEER to AP224 translator. (Recall: AP224 is/has a single conformance class.) This implementation is in use in the United Kingdom as part of the Ministry of Defence's UKRAMP Program and has been integrated with their process planning system. Currently, no other commercial or production implementations of AP224 are known. Several vendors have indicated possible interest in implementing AP 224 (including PTC, SDRC, UGSolutions, and Tecnomatix); none have initiated development to date. All are looking for a "business case" to arise. Such a business case may arise based on the integrated manufacturing suite scenario cited earlier which includes AP213, AP219, and ISO 14649, none of which have achieved IS status at this time.

The Shipbuilding and Process Industry Suites represent a significant user community throughout the world. These activities have had strong interest and support. There is high expectation that the STEP AP's evolving out of these efforts will be applied in these respective industries. Still to be determined is the intent of the vendor community to provide the STEP data exchange translators to cover these application domains. Once again, an industry driven business case will have to be presented in order for the vendor community to develop commercial translators for selected conformance classes of these AP's.

So, the question of **<u>when</u>** to use **<u>what</u>** AP and **<u>why</u>** depends, at this point, on the development status of the various AP's and the availability on the CAD systems of interest. The only commercially available STEP translators address geometry and some configuration management data (Essentially AP203 cc's 2, 4, 6 and a subset of cc 1). There is considerable "experimenting"/testing going on with prototype implementations of STEP AP's that have reached varying stages of completion in the development and standardization cycle. There is some experimentation going on in the CAx-IF with "STEP" Application Modules (e.g., colours and layers, validation properties, associative text,…) in combination with AP203. The Application Module (AM) Architecture is being worked hard with the anticipation that Vendors would be more willing to implement "small" "plug and play" modules that can leverage common elements of numerous AP's and be combined in different combinations to achieve functionality equivalent to Application Protocols. The granularity and the number of these application modules required to achieve this goal is still to be determined. A preliminary listing of initial AM's has been developed. Nine (9) of these AM's (including colours and layers) have been balloted as ISO Technical Specifications (See earlier list on pp. 16 - 17). STEP AP's currently under development are being encouraged to use the Application Module approach.

The user is encouraged to examine the scopes and associated conformance classes of the STEP Application Protocols that have reached IS status (and those about to reach IS status) to determine which, if any, will meet data exchange needs. Then, a review of the commercially available STEP translators, and the conformance class(es) implemented will determine if a STEP solution is available.

The PDES, Inc. STEPnet and PDMnet and ProSTEP Round Table/Rally testing have done much to ferret out and resolve translation problems and to stabilize the commercial translators for AP203 and AP214 (cc's 1 & 2) and to reach consensus on the STEP PDM schema. Reliability and performance have improved greatly and led to some recommendations and hints.

(From the PDES, Inc. Public Web Site)

"The CAx Implementor Forum is a joint testing effort between PDES, Inc. and ProSTEP. The objective of the forum is to accelerate CAx translator development and ensure that user's requirements are satisfied. The CAx Implementor Forum is an approach to establish a common test activity in the CAD area by merging PDES, Inc.'s STEPnet and ProSTEP's CAD Round Table. The goals of the CAx Implementor Forum are to:

- Implement functionality for today's needs
- Identify functionality for tomorrow's needs
- Avoid roadblocks by establishing agreed upon approaches
- Increase user confidence by providing system and AP interoperability testing
- Ensure new functionality does not adversely impact existing implementations

The CAx Implementor Forum and PDM Implementor Forum are significantly improving STEP translator quality and decreasing translator time-to-market."

Poor model quality, not STEP itself, remains one of the major barriers to the production use of STEP. "Many STEP translation failures and errors occur due to user modeling practices and/or CAD System algorithm errors." (http://www.tbailey.net/appendix.htm)

"**A Check List for Data Exchange** (From Theorem Solutions Web Site)

1. During the dialogue between receiver and sender the following points need to be covered:
2. Define the purpose of the transfer, e.g. design modification, machining.
3. Define number of models/drawings.
4. Define the volume of data to be converted.
5. Define scope of transfer, e.g. 2D/3D or both
6. Associativity to be maintained?
7. Define acceptance limits for the transfer.
8. Check Drawing Office practices.
9. Check the magnetic media to be used.
10. Check the operating system environments, i.e. UNIX, NT or other.
11. Agree which data compression utilities (if any) will be used.

12. Check CAD systems and versions.
13. Check versions of the converters to be used.
14. Is a process required to be established or is it a one-off transfer?
15. For each converter to be used check:
16. Which CAD entities are covered by the converter.
17. Check which entities will be created from each CAD entity translated.
18. What options does the converter have?
19. What version of data is created?

If a standards-based solution is used, requiring two processors, check:

1. Which entities are converted to CAD entities.
2. Check which CAD entities are created from each neutral file entity translated.
3. What options do the pre- and post-processors have?
4. What version of the neutral format can be read. "

"General Information and Techniques for Improving STEP Translation Success
(From the PDES, Inc. CAx-IF Website @ http://www.cax-if.org/bestprac/practice.html)

Modeling

- Use entity types that are supported by your translator or defined in exchange agreements
- Wherever possible use basic geometry and primitive solids to create the model
- Avoid modeling practices that can create geometry which cannot be exchanged, as in constructing solids where topological edges converge at a single degenerate point
- Use the highest precision when creating a part
- Most CAD vendors today implement AP 203 (configuration managed 3D design data), Conformance classes 2, 4, and 6
  - Class 6 is advanced boundary representation solids
  - Class 4 is topologically bounded surfaces
  - Class 2 is geometrically bounded wireframe and surfaces
- AP 214 implementations so far have mainly copied AP 203 geometry
- Use b-rep solids since facetted boundary representation solids corresponds with the little-implemented AP 203 class 5
- If you must use wireframe, make it geometrically bounded since topologically bounded wireframe corresponds with the virtually unimplemented AP 203 class 3

Importing STEP Files

- Confirm that files are defined to the agreed standard
- Verify that files have not undergone any conversions that may have corrupted them, e.g. ASCII to EBCDIC conversion can convert special characters, which have a meaning in STEP files
- Ensure that files have not been truncated, e.g. to 80 character records, or in length

Exporting STEP Files

- For assemblies, confirm that all component files are in the same directory
- Make all geometry visible and selectable
- Remove unnecessary geometry, layers, annotation from the file(s)
- Use tools available in the native system to validate geometry prior to export

- Ensure that the STEP translator can support the nature of the data to be exchanged"

Some User Guidelines/Hints/Analysis Websites:

- **CoCreate** - STEP Rec Settings --- http://www.cocreate.com/module/dataexchange/Recommendations/CAD-CAD_reco_STEP_set.html
- **PDES, Inc.** Best Practices Guidelines (PDES, Inc. - Public) --- http://www.cax-if.org/bestprac/practice.html
- **ProSTEP** Best Practices Guidelines (ProSTEP - PI Public) --- http://public.prostep.de/BP/
- **T. Bailey Consultants**
  - ⇒ General Info STEP --- http://www.tbailey.net/appendix.htm
  - ⇒ Situation Analysis --- http://www.tbailey.net/newpage3.htm
  - ⇒ Best Practices for exporting solids from UG using STEP --- http://www.tbailey.net/newpage4.htm
- **UKCEB/UKCIC Hints**
  - ⇒ http://www.ukcic.org/step/pages/hints_data.htm
  - ⇒ http://www.ukcic.org/step/pages/hints_modelling.htm

8.0 Certification of STEP Translators

Some sort of "Official" Certification for STEP Translators has always been a goal of the ISO STEP community. The definition of certification has been an issue. Is it simply semantic and syntactic conformance to the AP's schema and STEP's syntax? The requirement for and the development of Abstract Test Suites (ATS) provide the basis for certifying a STEP translator for a specified conformance class of a specified AP.

Agreements have been reached within the ISO TC184/SC4 STEP community on what constitutes certification of a STEP translator and an agreed upon process for determining certification. A 1999 Memorandum of Understanding (MOU) signed by the four STEP Centers: PDES, Inc. (USA), GOSET (France), JSTEP Japan), and C-STEP (China) supporting STEP Certification. The U. S. Product Data Association (USPRO) has been designated as the administrator for the STEP Certification Program and the Center for Electronic Commerce (CEC) at the Environmental Research Institute of Michigan (ERIM) has been designated to conduct the certification testing and to validate the results.

The procedures are designed to be performed electronically with a mechanism for conducting sample self-testing prior to initiating the "real" certification test. Translators can be certified as preprocessors (generating STEP files) and/or as postprocessors (reading in the STEP file). Official STEP Certification testing was initiated in 1999 and to date, four Vendor translators have been bi-directionally certified for AP203 cc 6a where the "a" designates the "agreed upon" minimal subset of cc1 configuration management data. The certified translators are Dassault's CATIA, UGSolutions' UNIGRAPHICS, Autodesk's Mechanical Desktop, and Theorem Solutions' CADDS5. Note: at this time, AP203 cc6a is the only STEP AP and conformance class that the STEP Certification Bureau is able to certify.

STEP Certification for translators will be based on ATS Test Cases for each AP and conformance class. As noted, the USPRO/ERIM-CEC Certification is currently only performing certification testing for AP203 cc 6a (i.e., Advanced B-Rep with minimum subset of CM (cc 1)). Eventually, as more Abstract Test Suites become available and commercial translators for more STEP AP conformance classes are developed, more comprehensive certification coverage (in theory) will also become available.

STEP Translator Certification Information --- (http://stepcert.erim.org)

"This website can be used to conformance test STEP based software products. Successful completion of testing is required for official USPRO certification of the products. Follow the procedure to register for testing, completing the tests, and seeking USPRO certification.

Contact USPRO for information and application proformas. Upon completion of the application process with USPRO, you will receive a login account and password to enter this web site and use it for conformance testing. Your account will be private and accessible only to you and support staff in the CEC. If you have questions, you could contact USPRO or the CEC.

US PRO Trident Research Center, Suite 204
5300 International Boulevard
North Charleston, SC 29418
Fax: +1 803-760-3349
Email: stark@aticorp.org "

Summary

The development and implementation of STEP Standards is dynamic and on-going. This handbook represents a “snap shot” of the information as it exists at this point in time.

This handbook is a collection of information on the current state of STEP and it’s current usability. It's intent was to provide information of value to engineering users with a need to exchange product data with customers and/or suppliers.

The handbook concentrated on identifying the application domains being covered by STEP development, identifying commercially available tools for using STEP, providing guidance on using the STEP technology that is currently available, and providing sources of additional information.

The current status of STEP development was presented with emphasis on those parts of STEP that have achieved International Standard (IS) status and those parts that will soon reach that status. The scopes of these STEP Application Protocols (AP's) are presented to indicate what is and isn't addressed in the AP's. This information was presented so that the engineering user was able to see the depth of coverage of the AP's and to identify those STEP AP's and their associated conformance classes that best will meet the user's product data exchange (PDE) requirements.

A table is provided showing commercially available PDE translators from the major CAD/CAM vendors. This table includes STEP translators as well as direct translators and translators that use other PDE formats.

At this point in time, commercial implementation of STEP is mainly limited to several conformance classes of AP203 - Configuration Controlled Design and two conformance classes of AP214 - Core Data for Automotive Mechanical Design Processes which are roughly equivalent to AP203. Reference is made to those major companies who have put this current STEP capability into production.

Numerous pilot, prototype and proof-of-concept implementations of the many STEP Application Protocols were cited to emphasize the successful demonstration of the power and robustness of the evolving STEP standards.

An attempt was made to distinguish between what is “real” now and what is theoretically possible (& achievable) in the future and to identify some of the current obstacles to achieving the ultimate goal of STEP. (i.e., to provide a complete, unambiguous, neutral computer-interpretable standard for representing product data throughout the lifecycle of the product.)

Some guidance was provided for the engineering user in using the currently available STEP capability. Some hints, guidelines and checklists were provided and referenced to assist in using the currently available STEP technology.

The STEP that is commercially available to the engineering user community is essentially AP203 and its "look alike" AP214 cc 1&2 (i.e., geometry (wireframe, surfaces & solids) with some configuration management data). What is available is really very good --- good enough to be in production at Boeing, Lockheed Martin, General Motors, General Electric, Pratt & Whitney, Rolls Royce and other large companies. But STEP presents a much more powerful and robust technology that has been and is being demonstrated in numerous Research & Development environments.

STEP is frequently misunderstood in the general engineering user community. It is still evolving, and STEP is now at a point in its evolution when a significant number of Application Protocols are reaching International Standard status. Three AP's were published as IS's in 1999 and six more are expected in 2000. STEP is and will be more than AP203. The user community will now have to start looking more closely at the AP's and their associated conformance classes (cc's) to determine what components/parts of STEP best meet their requirements. Users are going to have to start referring to STEP by AP and cc. In order to realize the "full" power of STEP, the user community will have to drive vendor implementation of the AP conformance classes that they will need to meet their business objectives. In order for this to happen, strong business cases are going to have to be developed in order to get the CAD/CAM/CAE Vendors on board.

The handbook concentrated on identifying the application domains being covered by STEP development, identifying commercially available tools for using STEP, and providing guidance on using the STEP technology that is currently available. It addressed those STEP Application Protocols (AP's) that have achieved (or "very soon" will achieve) International Standard (IS) status, those AP's that are currently implemented and have commercially available translators, and those AP's that have been or are currently being piloted, prototyped, or proved-out.

9.0 References

Documents

1. The Economic Benefits of Advanced Product Data (Draft), DL910T1, Michelle M. Kordell & Eric L. Gentsch, Logistics Management Institute, December 1999.

2. The Applicability of STEP to Automotive Design and Manufacturing, Automotive Industry Action Group (AIAG) D-10, March 10, 1998.

3. Final Report for STEP Driven Manufacturing at Small and Medium Manufacturers Pilot Project, DLA RAMP Program, Team SCRA, July 15, 1997.

4. RAMP Site Proveout of STEP Filesets Project - Phase 1 (June 8, 1994 - February 24, 1995)(Final Report-General Release), TAR2017005-0, RAMP Program, Team SCRA, (Reproduced & Distributed by USPro), March, 1995.

5. RAMP Site Proveout of STEP Filesets Project - Phase 2 (February 25, 1995 - July 17, 1996)(Final Report), TAB2017009-0, RAMP Program, Team SCRA, March 26, 1997.

6. Product Data Exchange Technologies Success Story Booklet, IGES/PDES Organization (IPO) Workshop, Gaithersburg, Maryland, January 27, 1997.

7. RAMP Technology Transfer Pilot Program (Final Report), Texas Instruments Defense Systems and Electronics, November 21, 1996.

8. Rapid Acquisition of Manufactured Parts Pilot Project (Final Report), Team SCRA & Focus:HOPE, July 31, 1997.

9. The Historical Need for STEP (A White Paper), Howard Mason (British Aerospace)

10. STEP Development Methods, (A White Paper), Julian Fowler (CADDETC-Fomerly), March 7, 1995.

11. STEP:Towards Open Systems-STEP Fundamentals and Business Benefits, Dr. Kais Al-Timimi & John MacKrell, CIMdata, September, 1996.

12. Introducing STEP - The Foundation for Product Data Exchange in the Aerospace and Defence Sectors, National Research Council Canada, C2-447/1999, Susan Gilles (ed), 1999.

13. STEP-The Grand Experience, NIST, Sharon J. Kemmerer (ed.), July 1999

14. STEP-The Future of Product Data Exchange (An AIAG Booklet), Dick Justice, Russell Doty & Mike Strub, 1995.

15. On-demand manufacturing of Printed circuit assemblies Using STEP (OPUS), W. B. Gruttke, W. B. Freeman, C. T. Lanning & K. D. Buchanan, EMI, April 1999.

16. STEP-Driven Manufacturing, CASA/SME Blue Book Series, John H. Bradham, 1998.

17. Fundamentals of STEP Implementation, Dave Loffredo, STEP Tools, Inc., http://www.steptools.com/library/fundimpl.pdf

Web Sites

1. Team SCRA - RAMP Product Data --- http://ramp.scra.org/pdt_summary.html

******* STEP Centers *******

2. Australasian STEP Data Exchange Centre (AUSDEC) --- http://www.ausdec.com.au/
3. European STEP Centers Network (ESCN) --- http://www.uninova.pt/~escn/
4. Fujitsu STEP Research & Development Center --- http://www.fqs.co.jp./STEP/
5. Italian STEP Center (CeSTEP) --- http://www.cestep.polito.it/
6. Japanese STEP Promotion Center --- http://www.jstep.jipdec.or.jp/
7. PDES Inc. Public Website --- http://pdesinc.aticorp.org/
8. ProSTEP --- http://www.prostep.de/
9. STEP Akeda Laboratory (Japan) --- http://www.hike.te.chiba-u.ac.jp/ikeda/documentation/STEP.html
10. STEP in Finland ---
    http://cic.vtt.fi/links/step.html
    http://cic.vtt.fi/links/euproj.html
11. Swedish STEP Centre (SwedSTEP)--- http://www.psm.kth.se/swedstep/
12. UK CALS Industries Council (UKCIC) Website --- http://www.ukcic.org/step/step.htm
    aka UK Council for Electronic Business (UKCEB) (Home Page) --- http://www.ukcic.org/step/
13. Worldwide STEP Projects --- http://www.marchland.com/piebase/project/index.htm

******* Standards Organizations *******

14. ANSI --- http://www.ansi.org/
15. GOSET --- http://www.goset.asso.fr/
16. ISO --- http://www.iso.ch/
17. NIST --- http://www.nist.gov/welcome.html
18. NIST SC4 On-Line Information Service (SOLIS) --- http://www.nist.gov/sc4/
19. SC4 Project Management Database --- http://www.nist.gov/sc4/status/pmdb/current/
20. US Product Data Association (USPro) --- https://www.uspro.org/

******* Information, Overviews, Summaries *******

21. CoCreate - STEP Rec Settings ---
    http://www.cocreate.com/module/dataexchange/Recommendations/CAD-CAD_reco_STEP_set.html
22. NIST SC4 Website (Updated 2000-02-08): --- http://www.nist.gov/sc5/soap/ --- STEP On A Page
23. PDES, Inc. Helpful Pub's --- http://pdesinc.aticorp.org/aps.html
24. PDES, Inc. STEP Overview --- http://pdesinc.aticorp.org/whystep.html
25. ProSTEP Best Practices --- http://public.prostep.de/BP/bp_syskomb2.htm
26. STEP ISO 10303 Data Exchange Links ---
    http://home.earthlink.net/~stevenlalexander/step_links.html
27. T. Bailey Consultants --- http://www.tbailey.net/appendix.htm
28. Theorem Solution White Papers --- http://www.theorem.co.uk/docs/standard.htm

******* Tools *******

29. EPM Technology Products --- http://www.epmtech.jotne.com/products/index.html
30. InterData Access (IDA) (Spatial Technology) --- http://www.spatial.com
31. International TechneGroupe Inc. (ITI) --- http://www.iti-oh.com
32. PDTec Products --- http://www.pdtec.de/
33. STEP Tools, Inc. --- http://www.steptools.com/
34. STEP Tools, Inc. Products --- http://www.steptools.com/products/
35. STEP Tools, Inc. Translation Service --- http://www.steptools.com/strepo/translate.cgi

******* Vendors *******

36. Alias Wavefront --- http://www.aliaswavefront.com/design/products/consumer_products/designstudio/pdf_brochure/index.pdf
37. Autodesk Data Exchange Products --- http://www.autodesk.com/products/dataexch/index.htm
38. Autodesk - XchangeWorks --- http://www.xchangeworks.com/
39. CATIA/CADAM Interface Products --- http://www.catia.ibm.com/prodinfo/fniface.html#dxf
40. CoCreate Data Exchange Formats --- http://www.cocreate.com/english/products/3d/pse.htm
41. IBM Data Exchange Services --- http://service.software.ibm.com/indsolutns.us/go?/mktdocs/support/igesserv.html
42. MicroCADAM Helix2000 --- http://www.microcadam.com/product/H2000/H2000.html
43. PTC Pro/E Interfaces --- http://www.ptc.com/products/proe/foundation/interfaces.htm
44. SDRC STEP Data Exchange --- http://www.sdrc.com/pub/catalog/ideas/data-exch/step/index.html, http://www.sdrc.com/nav/software-services/artisan/factsheets/step.pdf
45. Solid Edge Translators --- http://www.solid-edge.com/prodinfo/v7/interop.htm
46. Solid Edge Website --- http://www.solid-edge.com/_vti_bin/shtml.dll/_Components/forms/search.htm
47. UGSolutions Data Exchange Services --- http://www.ugsolutions.com/services/data_exchange/
48. UGSolutions Products --- http://www.ugsolutions.com/products/unigraphics/products.shtml, http://www.ugsolutions.com/products/unigraphics/data_exchange/, http://www.ugsolutions.com/products/parasolid/, http://www.ugsolutions.com/products/bravo/pdm.shtml
49. UGSolutions Support --- http://support.ugsolutions.com/
50. Theorem Solutions --- http://www.theorem.co.uk/

******* Industry Group *******

51. AIAG --- http://www.aiag.org/

******* Other *******

52. IMTECH View Formats --- http://www.imtechdesign.com/3dview/cadformats.html

APPENDIX

(Additional Conformance Class Details for Specific AP's)

AP210 Conformance Classes:

Conformance to this part of ISO 10303 requires conformance to one of the following:

- any combination of the conformance classes 1 through 7
- conformance class 8
- any combination of the conformance classes 9, 10, 24
- any combination of the conformance classes 24 through 29
- any combination of the conformance classes 13, 14

Conformance class 12 may be used for ISO 10303-210.

Conformance classes 15 through 23, and class 30, are shape representation conformance classes that may be used for ISO 10303-210.

Conformance to a particular conformance class requires that all AIM entities, types, and associated constraints defined as part of that class be supported.

Conformance to a particular conformance class requires conformance to each conformance class included in that class. All entities specified, either directly or indirectly, by required attributes of the required AIM entities shall be supported.

Conformance to a particular conformance class requires that all ARM constraints for UoFs implemented by this class be supported.

cc 1: Device Functional and Physical Characterization

Device Data includes following information: device black box model, package data, functional data, environmental constraints, performance data, simulation models. Formal encapsulation of external data type definitions is made for parametric data and analysis models. Pin mapping is provided to ensure consistency between device views. Shape, material, technology, tolerance on shape and on parameters, units are included.
Shapes included may be categorized according to discipline (e.g. thermal analysis, vibration analysis), and analysis environment (e.g., design, assembly, end-user). Geometric Dimensioning and Tolerancing is included.
The functional data includes two distinct data sets: hierarchical functional decomposition into behavioural elements embedded in a network represented at each level by a nodal formulation; collection of device terminals (e.g., connector terminals, printed circuit board interface areas, jumper ends) that implement the functionality of a network node. Configuration management information and design management information is provided.
This data includes at least one geometric representation.

cc 2: Interconnect Technology Constraints

This Data includes all information provided to the design team by fabrication vendors from which may be derived default land and passage definitions, based on the desired yield for fabrication and assembly processes. Typical Data includes minimum annular ring, maximum passage aspect ratio, minimum deposition thickness, maximum terminal size supported for through hole technology class, and other critical material processing properties. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 3: Assembly Technology Constraints

This Data includes all information provided to the design team by assembly vendors from which may be derived constraints on which packages may be selected, mounting arrangements to be specified, permitted mounting areas, clearances, etc. Typical bond shape for each unique assembly process is available. Extensive use of formal encapsulation of external data type definitions is made for parametric data. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 4: Assembly Functional Requirements

This Data includes all information required to specify the behaviour of the assembly, including interface definition. Explicit structural definition is provided for the functional network, including representations of usage view and design view, representations of folded and elaborated network hierarchy. This includes gate allocation information. Explicit allocation of each functional network node to the implementing component is included. Extensive use of formal encapsulation is provided for signal definition, mathematical models, etc. This data includes information required to support embedded components in an interconnect product. Configuration management information and design management information is provided.

cc 5: Assembly Physical Requirements

This Data includes all information provided to the design team that may be represented by shape data, including customer requirements, and technology selected to implement those requirements. Explicit allowed volumetric shape, external connection locations are included. Component grouping, keepout, keepin, etc is included. This data includes information required to support embedded components in an interconnect product. Configuration management information and design management information is provided. Preferred parts and packages may be specified by inclusion in design library. This data includes at least one geometric representation.

cc 6: Interconnect Functional Requirements

This Data includes the device data from conformance class 1 (only the functional device information) specific to an interconnect product (e.g., pcb, substrate, flex board). The functional view of Devices which are fabricated as part of the interconnect product fabrication process (e.g., printed inductors, printed connectors, printed capacitors) are included in the functional definition. Devices which are embedded are considered to be external to the interconnect product since they are not fabricated as part of the product and their shape does not directly contribute to the shape definition of the interconnect product. Configuration management information and design management information is provided.

cc 7: Interconnect Physical Requirements

This Data includes all information related to shape and position requirements. Trace, via and other passage spacing, keepin, keepout, etc. is included. Explicit allowed volumetric shape, required connection locations, material specifications, etc. are included. Those layout items whose placement is driven by thermal considerations or electromagnetic interference may be specified. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 8: Assembly Physical Design

This data includes all data that defines the physical relationships between the components in the assembly. This data includes all the components that exist in the assembly, and specifies those that provide physical interfaces to the next level of assembly. Several types of assembly joint may be specified. Design re-use is explicitly supported with traceability. Complete traceability back to requirements is provided. This data identifies those components that do not meet design requirements. Appropriate elements of Geometric Dimensioning and Tolerancing are provided. This data includes both design view and usage view of the assembly. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 9: Interconnect Design

This data provides functional and physical layout information sufficient to allow manufacture and test of an interconnect. Design re-use is explicitly supported with traceability. Complete traceability back to requirements is provided. Product connection requirements, shape requirements, product specifications, process specifications, material specifications including manufacturing view of stackup, Geometric Dimensioning and Tolerancing are provided. This data identifies those elements that do not meet design requirements. This data includes both design view and usage view of the interconnect product. Support for specification of signal prioritization is provided. Support for specifying the explicit network topology to be implemented is provided. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 10: Interconnect Design (Microwave)

This data is similar to Class 9, with the exception that the metallization may be considered to be microstrip or stripline, with a specified shape element of the cross-section(i.e., point, edge, cutting plane) acting as the terminal(terminal pair, port) of the line or component. Use of formal external definitions is provided to link in models with the product definition data. Analytical model terminals may be distributed. This data identifies those elements that do not meet design requirements. This data includes both design view and usage view of the interconnect product. Support for specification of signal prioritization is provided. Support for specifying the explicit network topology to be implemented is provided. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 11: Geometric Dimensioning and Tolerancing

This data includes the 14 geometric tolerances in ISO 1101. Angularity, circularity, circular run-out, concentricity, cylindricity, flatness, parallelism, perpendicularity, position, profile of any line, profile of any surface, straightness, symmetry, and total run-out. This data includes dimension, limits and fits. This data includes datum system definition. This data includes the tolerance zones in ISO 1101 and ASME Y14.5.(e.g., cylindrical, parallelepiped, projected, and conical). Configuration management information and design management information is provided.

cc 12: Product Rule

This data includes support for rule creation, management, assignment to product data or features, assignment to product or requirement parameters. Complete specification of this capability is deferred until the expression work integration is completed. Configuration management information and design management information is provided.

cc 13: Functional Decomposition

This data includes specification of the folded and unfolded (elaborated) hierarchical product definition in the functional view. Support is provided for a usage view and a design view. The ability to exchange data defining a functional test bench and functional specification based on signals is included. Signal definition relies on external definition, but signal properties may be represented. Support is provided for both lumped element and distributed port properties. Analysis models may be included in the exchange structure with close integration accomplished by pin mapping. Configuration management information and design management information is provided.

cc 14: Package Functional and Physical Characterization

Package Data includes following information: Case style, material identification, environmental constraints, performance data, simulation models. Formal encapsulation of external data type definitions is made for parametric data and analysis models. Terminal identification is provided to ensure consistency between device views. Package body material is included. Terminals may have core and surface materials. Shape, material, technology, tolerance on shape and on parameters, units are included. Shapes included may be categorized according to discipline (e.g, thermal analysis, vibration analysis), and analysis environment (e.g., assembly, end-user). Geometric Dimensioning and Tolerancing is included. Complex packages may be treated by the design owner as an interconnect product and publish the information in package as the customer view. Formal Reference information to a defining document is provided. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 15: Geometrically Bounded Surface Model

This class shall not be implemented by itself.

- The class requires the implementation of the following Units of Functionality:
- geometrically_bounded_2d_wireframe
- non_topological_surface
-

cc 16: Wireframe Model With Topology

This class shall not be implemented by itself.

- The class requires the implementation of the following Units of Functionality:
- wireframe_2d_model_with_topology
- wireframe_with_topology
-

cc 17: Advanced Boundary Representation

This class shall not be implemented by itself.

- The class requires the implementation of the following Units of Functionality:
- advanced_boundary_representation
-

cc 18: Constructive Solid Geometry

This class shall not be implemented by itself.

- The class requires the implementation of the following Units of Functionality:
- constructive_solid_geometry

cc 19: Extruded Solid

This class shall not be implemented by itself.

- The class requires the implementation of the following Units of Functionality:
- solid_of_linear_extrusion

cc 20: Geometrically Bounded 2d Wireframe Model

This class shall not be implemented by itself.

cc 21: Wireframe 2d Model With Topology

This class shall not be implemented by itself.

cc 22: Curve 2d

This class shall not be implemented by itself.

cc 23: Basic Curve 2d

Includes Only Lines, Circle and Arc Subtype of Conic. This class shall not be implemented by itself.

cc 24: Laminate Assembly Design

This data provides physical assembly information sufficient to allow communication of the arrangement of laminates in an interconnect product, and required interconnections among the materials assembled. Configuration management information and design management information is provided.

cc 25: Connection Zone Based Model Extraction

This data provides information sufficient to allow communication of the explicit geometric basis for connection points of analysis models. Configuration management information and design management information is provided.

cc 26: Functional Specification

This data provides information sufficient to allow communication of the behavioural specification of product functions. Formal encapsulation of external data type definitions is made for parametric data and signal characterization. Configuration management information and design management information is provided.

cc 27: Physical Unit Physical Characterization

Physical Unit Physical Characterization data includes following information: Material identification, environmental constraints, performance data, simulation models. Formal encapsulation of external data type definitions is made for parametric data and analysis models. Shape, material, technology, tolerance on shape and on parameters, units are included. Shapes included may be categorized according to discipline (e.g, thermal analysis, vibration analysis), and analysis environment (e.g., assembly, end-user). Geometric Dimensioning and Tolerancing is included. A Formal Reference capability to the defining document is provided. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 28: Packaged Part White Box Model

Packaged Part White Box Model Data includes following information: device model, package data, functional data, environmental constraints, performance data, and simulation models.

Assembly arrangement of devices included in the package to compose the packaged part is explicitly provided. Mapping of analysis model connection points to package terminals is provided. Formal encapsulation of external data type definitions is made for parametric data and analysis models. Pin mapping is provided to ensure consistency between device views. Shape, material, technology, tolerance on shape and on parameters, units are included. Shapes included may be categorized according to discipline (e.g. thermal analysis, vibration analysis), and analysis environment (e.g., design, assembly, end-user). Geometric Dimensioning and Tolerancing is included. The functional data includes two distinct data sets: hierarchical functional decomposition into behavioural elements embedded in a network represented at each level by a nodal formulation; collection of device terminals (e.g., connector terminals, printed circuit board interface areas, jumper ends) that implement the functionality of a network node. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 29: Printed Part Functional and Physical Characterization

Printed Part Data includes following information: device model, layout template data, functional data, environmental constraints, performance data, simulation models. Mapping of analysis model connection points to printed part terminals is provided. Formal encapsulation of external data type definitions is made for parametric data and analysis models. Pin mapping is provided to ensure consistency between device views. Shape, material, technology, tolerance on shape and on parameters, units are included. Shapes included may be categorized according to discipline (e.g. thermal analysis, vibration analysis), and analysis environment (e.g., design, assembly, end-user). Geometric Dimensioning and Tolerancing is included. The functional data includes two distinct data sets: hierarchical functional decomposition into behavioural elements embedded in a network represented at each level by a nodal formulation; collection of device terminals that implement the functionality of a network node. Configuration management information and design management information is provided. This data includes at least one geometric representation.

cc 30: Open Shell Model

This class shall not be implemented by itself.

- The class requires the implementation of the following AIM entities:
- manifold_surface_shape_representation

AP212 Conformance Classes:

cc 1: Configuration Controlled Design and Documentation

This conformance class supports the following areas:

- "classification and item designation;
- configuration controlled design
- documentation using two-dimensional schematic diagrams;
- product oriented connectivity;
- product structure;
- work flow related information.

This conformance class describes the equipment used in an electrotechnical system and its documentation throughout all stages of the design of the system and its installation."

cc 2: Functional Aspects and Information Flow

This conformance class supports the following areas in addition to the content of CC1:

- "allocation of the functional aspects to the physical aspects of the design;
- functional aspects of the electrotechnical system;
- functional networks;
- information flow in the electrotechnical system.

This conformance class describes the functional aspects of an electrotechnical system throughout all stages of the design of the system and its installation."

cc 3: Installation and Arrangement of Electrotechnical Equipment

This conformance class supports the following areas in addition to the content of CC1:

- "documentation using two-dimensional dimensioned drawings;
- information related to the arrangement and positioning of the equipment;
- installation of the system.

This conformance class describes the spatial aspects of an electrotechnical system throughout all stages of the design of the system and its installation and its documentation."

cc 4: Description of the Entire Electrotechnical System

This conformance class supports the information content of cc 1 to cc 3.

This conformance class provides information about all aspects of an electrotechnical systems throughout its design and installation.

AP214 Conformance Classes:

cc 1: Component design with 3D shape representation

This conformance class supports the following areas:

- component design of car body, power train, chassis, or interior parts;
- component design of tools.

This conformance class includes requirements that match those defined in the conformance classes 2, 4, 5, and 6 of ISO 10303--203, with the additional requirement for geometric presentation (P1), csg model (G7), and element structure (S2). In the area of configuration control information this conformance class requires product management data (S1), which is a subset of conformance class 1 of ISO 10303--203.

cc 2: Assembly design with 3D shape representation

This conformance class supports the following areas:
-- conceptual design including assembly definitions;
-- mountability examination;
-- packaging layout.
This conformance class includes requirements that match those defined in the conformance classes 2, 4, 5, and 6 of ISO 10303--203, with the additional requirement for geometric presentation (P1), csg model (G7), element structure (S2), and external

reference mechanism (E1). In the area of configuration control information this conformance class requires product management data (S1) and item definition structure (S3), which is a subset of conformance class 1 of ISO 10303-203.

cc 3: Component drawings with wireframe or surface shape representation

This conformance class supports the following areas:
-- component drawings or sketches for car body or some interior parts;
-- component drawings or sketches for tools.
This conformance class includes requirements that match those defined in ISO 10303-201, with additional requirements for wireframe model 3d (G2) and connected surface model (G3).

cc 4: Assembly drawings with wireframe, surface or solid shape representation

This conformance class is suitable for use in the following areas:
-- component or assembly drawings for power train, chassis, or interior parts;
-- component or assembly drawings for tools.
This conformance class includes requirements that match those defined in the conformance classes 3, 5, 7, 9, and 10 of ISO 10303--202, with the additional requirement for item definition structure (S3), external reference mechanism (E1), and csg model (G7).
This conformance class includes the requirements as defined for the conformance classes 2 and 3 of this part of ISO 10303.

cc 5: Styling data

This conformance class is suitable for use in the following areas:
-- digital mockup;
-- styling.

cc 6: Product data management (PDM) without shape representation

This conformance class is suitable for use in the following areas:
-- product data management systems that manage CAD models as files;
-- administrative data of parts, assemblies, documents, and models.
This conformance class includes requirements that match those defined in the conformance class 1 of ISO 10303--203.

cc 7: Product data management (PDM) with 3D shape representation

This conformance class supports the following areas:
-- administrative data of parts, assemblies, documents, and models;
-- conceptual design including assembly definitions;
-- mountability examination;
-- packaging layout;
-- data exchange between product data management systems linked to CAD/CAM systems.
This conformance class includes requirements that match those defined in the conformance classes 1, 2, 4, 5, and 6 of ISO 10303--203, with the additional requirement for geometric presentation (P1), csg model (G7), element structure (S2), and external reference mechanism (E1).
This conformance class includes the requirements as defined for the conformance classes 2 and 6 of this part of ISO 10303.

cc 8: Configuration controlled design without shape representation

This conformance class is suitable for use in the following areas:
-- configuration control for power train, chassis, car body, or interior parts;
-- configuration control for tools.
This conformance class includes the requirements as defined for the conformance class 6 of this part of ISO 10303, with the additional requirement for specification control (S7).

cc 9: Configuration controlled design with 3D shape representation

This conformance class supports the following areas:
-- configuration control for power train, chassis, car body, or interior parts;
-- configuration control for tools;
-- administrative and configuration control data of parts, assemblies, documents, and models;
-- product data management systems for control of a large number of product variants.
This conformance class includes requirements that match those defined in the conformance classes 1, 2, 4, 5, and 6 of ISO 10303--203, with the additional requirement for geometric presentation (P1), csg model (G7), element structure (S2), external reference mechanism (E1), and specification control (S7).
This conformance class includes the requirements as defined for the conformance classes 7 and 8 of this part of ISO 10303.

cc 10: Configuration controlled design with shape representation and draughting data .

This conformance class supports the following areas:
-- configuration control and assembly drawings for power train, chassis, car body, or interior parts;
-- configuration control and assembly drawings for tools;
-- administrative and configuration control data of parts, assemblies, documents, and models;
-- product data management systems for control of a large number of product variants with links to CAD/CAM systems.
This conformance class includes the requirements as defined for the conformance classes 4 and 9 of this part of ISO 10303.

cc 11: Process planning of components

This conformance class supports process planning for components (piece parts) with shape and draughting data.
This conformance class includes the requirements as defined for the conformance class 1 of this part of ISO 10303, without the requirement for geometrically bounded surface model (G8), and the conformance class 3 of this part of ISO 10303, without the requirement for geometrically bounded surface model (G8), and the conformance class 3 of this part of ISO 10303.

cc 12: Process planning of components with form feature and tolerance data

This conformance class supports process planning data for components (piece parts) with shape, draughting, form feature, tolerance, and surface condition data.
This conformance class includes the requirements as defined for the conformance class 11 of this part of ISO 10303, with the additional requirement for user defined feature (FF1), pre defined feature (FF2), generative featured shape (FF3), surface condition (C1), dimension tolerance (T1), and geometric tolerance (T2).

cc 13: Effectivity controlled process planning of assemblies

This conformance class supports process planning with effectivity control for assemblies with shape, draughting, form feature, tolerance, and surface condition data.

This conformance class includes the requirements as defined for the conformance class 12 of this part of ISO 10303, with the additional requirement for item definition structure (S3) and effectivity (S4).

cc 14: Feature based design

This conformance class supports the following areas:

-- feature based conceptual design for components and assemblies, including manufacturing information such as tolerance and surface condition data;

-- feature based mountability examination.

This conformance class allows for identification of form features on the final shape of a component or of an assembly.

This conformance class includes requirements that match those defined in ISO 10303--224, with the additional requirement for geometric presentation (P1), wireframe model 3d (G2), connected surface model (G3), faceted b rep model (G4), csg model (G7), external reference mechanism (E1), and surface condition (C1).

This conformance class includes the requirements as defined for the conformance class 2 of this part of ISO 10303,

cc 15: Feature based design with flexible feature placement

This conformance class supports the following areas:

-- feature based conceptual design for components and assemblies, supporting efficient design changes through flexible feature placement;

-- feature based mountability examination.

This conformance class allows for an independent feature definition, e.g. in a feature library, and its usage through placement on the shape of a component or of an assembly.

This conformance class includes the requirements as defined for the conformance class 14 of this part of ISO 10303, with the additional requirement for generative featured shape (FF3).

cc 16: Kinematic simulations for components and assemblies with 3d shape representation

This conformance class supports the following areas:

-- collision detection;

-- support of kinematics modules of CAD systems.

This conformance class includes the requirements as defined for the conformance class 2 of this part of ISO 10303, without the requirement for geometrically bounded surface model (G8) and with the additional requirement for kinematics (K1) and item property (PR1).

cc 17: Measured data

This conformance class supports the following areas:

-- exchange of scanned (measured) data from a measuring system to a CAD/CAM system;

-- quality control.

cc 18: Configuration controlled process planning of components and assemblies with 3D shape representation and kinematic data

cc 19: configuration controlled process planning of components and assemblies with 3D shape representation including form features and kinematic data

cc 20: Data storage and retrieval systems

This conformance class supports database implementations to store, retrieve, or archive all of the data specified in this part of ISO 10303. Data manipulation functionality as performed in application systems is not expected to be implemented within the scope of this conformance class.

This conformance class includes all requirements as defined for the conformance classes 1 to 19 of this part of ISO 10303.

AP227 Conformance Classes:

cc 1: Piping System Functional Information

"This conformance class provides piping system functional information. This conformance class contains functional information of the piping system and catalogue reference information, but no shape or spatial information. This conformance class enables … exchange of functional information on plant piping systems. (The purpose of this conformance class is to provide an interface with ISO 10303 - 221 and piping functional design and schematics software.)"

cc 2: Equipment and Component Spatial Information

"This conformance class provides equipment and component spatial information. This conformance class contains basic equipment performance characteristics, connector location and orientation information, material specifications, version information, explicit shape, and catalogue reference information. This conformance class enables the exchange of minimal vendor equipment and component information."

cc 3: Plant Layout and Piping Design Information

"This conformance class provides plant layout and piping design information. This conformance class contains design, layout, and spatial information for the plant, and catalogue reference information. This conformance class enables the exchange of plant layout and piping design information for the following activities:

- Area classification;
- Space analysis;
- Plant arrangement (placement of space occupying elements);
- Spatial design of piping systems including pipe routing and component placement and placement of pipe supports;
- Operation and maintenance analysis;
- Constructability reviews;
- Interference checking;
- Development of equipment list and line list;
- Development of equipment takeoffs;
- Development of material takeoffs for piping and piping components;

- Connectivity and topology checks;
- Material and connection compatibility checks;
- Provision of spatial design information to support fabrication and construction;
- Spool and weld identification;
- Plant startup;
- Plant commissioning;
- Plant operation;
- Configuration management of plant items and piping system information.

Although not explicitly cited above, this conformance class also supports the activities listed for the other conformance classes."

cc 4: Piping Fabrication and Installation Information

"This conformance class provides piping fabrication and installation information. This conformance class contains system, plant item, and line identification, piping information, plant item characteristics and shape, and catalogue reference information. This conformance class enables the exchange of piping fabrication and installation information."